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LIEUT.-COL. ST. LEGER ALCOCK, Vice-President, in the Chair.

THE WORKING OF THE UNITED STATES' SANITARY COMMISSION WITH REGARD TO ARMIES IN THE FIELD.

By E. C. FISHER, Esq., United States' Sanitary Commission (English Branch).

THE Sanitary Commission of the United States may be said to have inaugurated a new era in the history of war. It has linked the volunteer philanthropy of the people to the unavoidable exclusiveness and stringent discipline of the army, and proved to the world at large that even women and children may largely add to the effectiveness of the soldier, thereby increasing the probabilities of victory. This self-organized association,—the offspring of the women of America, tutored by ministers of the Gospel and philanthropists, directed and supported by private enterprise and skill alone,—has unceasingly supplemented the medical service of the American army during nearly four years, compelling one of the principal surgeons to declare "We could not do without the Sanitary Commission." Such is the language of the Medical Inspector of the army of the Potomac, and I fear to commit no exaggeration in asserting, aside even from such high official authority,—that whatever success may have attended the Federal arms during this long and fearful struggle is due in large measure to the untiring exertions, sound judgment and liberality of this volunteer commission.

But while claiming credit for what has been effected by this almoner of the American people, I must admit that the idea of a Sanitary Commission was borrowed from a land which we speak of in the

United States as the "Old Country." It was England's experience in the Crimea and Hindostan which led us at the very commencement of the war to organize operations which you only began under the teachings of pressing necessity. Your troubles and misfortunes were a lesson to us from which it would have been strange had we not profited; and we therefore essayed at the very outset to *prevent* those evils from which you had suffered, and which were more likely to damage an army composed of volunteers than one of highly-disciplined regulars. Nor is it for this alone that we have to thank Englishmen. The practical teachings and saintly devotion of Florence Nightingale, the statesmanly skill and broad humanitarian counsels of the great and good Sidney Herbert were known and appreciated throughout the United States, and the people of America, addressed themselves to the work before them with all the benefit of your experience, taking up your work, as it were, where you had laid it down. We have "bettered the instruction." We have sought out channels of benevolence unthought of by you, perhaps because not formerly regarded as opportune or practicable. We return you your ten talents with other ten, in the name of one common humanity and race, believing that should England again have the misfortune to engage in war, the experience of your brethren in America will benefit your soldiers, and as largely increase the effectiveness of your army as it has done that of our own.

In view of the present relations of the United States' Sanitary Commission with the Government, it is hard to believe that the Commission had any difficulty in entering on existence. But it had to fight long and hard for that recognition without which existence was not possible. Governments are the same everywhere. Exclusiveness and jealousy of outside interference—call it by suggestion or by what name we will—are universally necessary to them. It was so most emphatically with the American Government when President Lincoln entered on office; yet I fear not to assert that no country at any period was more in need of such an organization as this Commission than the United States was at the commencement of the rebellion. There was no money in the Federal treasury, the national credit had become frightfully depreciated, the banking corporations declined at first to advance any loans, the Northern arsenals were emptied of their arms, which had been carried into the Southern States during President Buchanan's administration, the ships of the navy were scattered over the world on foreign stations or locked up in Southern ports, the whole North, in fine, was on an absolute peace establishment, and precisely in the position to require any help which could be offered. The Government was not alive to the magnitude of the crisis. Somebody said and many repeated, "it will all be over in ninety days." The President and his subordinates were new to official responsibility; what we possessed of regular troops were scattered amongst the Indian tribes on the frontier of civilisation, all the way from Oregon to Texas; the Army Medical Bureau was organized for a force of some 15,000 men; medicines, hospital furniture and necessaries were not in existence beyond the condition, as regards quantity, of

"samples," and yet notwithstanding the gravity of the situation, men in office checked unofficial suggestion as interfering and unnecessary. The President called upon the country for 75,000 volunteers. Farm labourers, clerks in counting-houses, artisans, men of all classes in civil life responded with alacrity to the appeal, volunteering in fact to relinquish the comforts of home and civilisation, for the hardships of campaigning in the deadly malarious regions of the South. They thought they had but to fight: they knew little or nothing of the havoc which disease makes in armies, and the Government, by force of circumstances, could not ward off disease from their ranks.

There is a maxim in political economy, "demand creates supply," which is equally applicable to military affairs. Necessity brought forth the sanitary commission, a bashful infant at first, destined ere long to grow into its present manly proportions, although its parents little thought at its nativity what a giant it would become. The women were the first to understand the gravity of affairs, and, if we may judge by their actions, it is safe to assert that they at least did not believe the war would be over in ninety days. They met in each others houses in the great centres of population, and of their own volition and inspiration organized themselves into Soldiers' Aid Societies, working the whole day through for the comfort and relief of the troops. Their labours were simple at first, but the basements of churches and many public buildings in the large cities of the North soon became filled to overflowing with the two articles of lint and bandages. But these women were not long in understanding that vastly more would be required for the army than merely these articles. What that more could be they could not tell, because the answer to the question fell within the province of man's experience alone. One of the first, if not the very first of the Soldiers' Aid Societies established, namely, the "Women's Central Association of New York," received the following sound advice from a clergyman of that city. "You want inquiry from the only correct sources. You must find out first what the Government *will* do and *can* do, and then helping it by working *with it*, and doing what it cannot. You must have advice derived from the Government." Meanwhile, the medical profession of New York had commenced moving in behalf of the army. Having the same object in view as the women, it was quickly decided to send a deputation to the authorities at Washington: three organizations were therein represented, that of the women above mentioned, the "Advising Committee of the Boards of Physicians and Surgeons of the Hospitals of New York," and the "New York Medical Association for furnishing Hospital Supplies in aid of the Army." The deputation consisted of four members, the clergyman, Dr. Bellows, now President of the Commission, who had given such sound advice to the Women's Association, and three of the most eminent of New York physicians. On the 18th of May, 1861, they presented a memorial to the Secretary of War praying for the appointment of a sanitary commission. The memorial in question concluded as follows:—

"It must be well-known to the Department of War that several

such Commissions followed the Crimean and Indian wars. The civilisation and humanity of the age, and of the American people demand that such a Commission should precede our second war of independence more sacred than the first. We wish to prevent the evils that England and France could only investigate and deplore. The war ought to be waged in a spirit of the highest intelligence, humanity, and tenderness for the health, comfort, and safety of our brave troops, and every measure of the Government that shows its sense of this will be eminently popular, strengthen its hands, and redound to its glory at home and abroad.

"The undersigned are charged with several distinct petitions, additional to that of asking for a commission for the purposes above described, although they would all fall under the duties of that commission.

"They ask that the Secretary of War will order some new rigour in the inspection of volunteer troops, as they are persuaded that, under the present state regulations throughout the country, a great number of under-aged and unsuitable persons are mustered, who are likely to swell the bills of mortality in the army to a fearful percentage, to encumber the hospitals, and embarrass the columns.

"The Committee represent that the Women's Central Association of Relief have selected, and are selecting, out of several hundred candidates, one hundred women, suited in all respects to become nurses in the general hospitals of the army. These women, the distinguished physicians and surgeons of the various hospitals in New York have undertaken to educate and drill in a most thorough and laborious manner; and the Committee ask that the War Department consent to receive, on wages, these nurses, in such numbers as the exigencies of the campaign may require. It is not proposed that the nurses should advance to the seat of war until directly called for by the Medical Bureau here, nor that the Government should be at any expense until they are actually in service.

"It is believed that a Commission would bring these and other matters of great interest and importance to the health of the troops into the shape of easy and practical adoption. But if no Commission is appointed the Committee pray that the Secretary will order the several suggestions made to be carried into immediate effect, if consistent with the laws of the department, or possible without the action of Congress.

"Feeling themselves directly to represent large and important constituencies, and, indirectly, a wide-spread and commanding public sentiment, the Committee would most respectfully urge the immediate attention of the Secretary to the objects of their prayer.

"Very respectfully,

"Henry W. Bellows, D.D.
"W. H. Van Buren, M.D.
"Elisha Harris, M.D.
"J. Harsen, M.D."

The proposal was not favourably received by the authorities

although the then Acting Surgeon-General of the Army, Dr. Wood, endorsed the prayer of the memorialists in the following terms:—

"The Medical Bureau would, in my judgment, derive important and useful aid from the counsels and well-directed efforts of an intelligent and scientific commission, to be styled 'A Commission of Inquiry and advice in respect of the Sanitary interests of the United States' Forces,' and acting in co-operation with the bureau, in elaborating and applying such facts as might be elicited from the experience and more extended observation of those connected with armies, with reference to the diet and hygiene of troops, and the organization of military hospitals."

Endorsement from such high authority nerved the deputation to press its demands, and a second memorial was forwarded to the Government defining the powers required for the proposed Commission and the objects it would endeavour to accomplish. These powers and objects were thus stated:—

"The Commission being organized for the purposes only of inquiry and advice, asks for no legal powers, but only the official recognition and moral countenance of the Government, which will be secured by its public appointment. It asks for a recommendatory order, addressed in its favour to all the officers of the Government, to further its inquiries; for permission to correspond and confer, on a confidential footing, with the Medical Bureau and the War Department, proffering such suggestions and counsels as its investigation and studies may from time to time prompt and enable it to offer.

"The Commission seeks no pecuniary remuneration from the Government. Its motives being humane and patriotic, its labours will be its own reward. The assignment to them of a room in one of the public buildings, with stationery and other necessary conveniences, would meet their expectations in this direction.

"The Commission asks leave to sit through the war, either in Washington or when and where it may find it most convenient and useful; but it will disband should experience render its operations embarrassing to the Government, or less necessary and useful than it is now supposed they will prove.

"The general object of the Commission is, through suggestions reported from time to time to the Medical Bureau and the War Department, to bring to bear upon the health, comfort, and *morale* of our troops the fullest and ripest teachings of sanitary science in its application to military life, whether deduced from theory or practical observation, from general hygienic principles, or from the experience of the Crimean, the East Indian, and the Italian wars. Its objects are purely advisory.

"The specific points to which its attention would be directed may here be partly indicated, but in some part may depend upon the course of events, and the results of its own observations and promptings when fairly at work. If it knew precisely what the results of its own inquiries would be, it would state them at once, without asking for that authority and those governmental facilities essential to a successful investigation of the subject. As the Government may select its

own commissioners—the persons named in the recommendation of the Medical Bureau being wholly undesirous, however willing, to serve, if other persons more deserving of the confidence of the Government and of the public can be nominated—it is hoped that the character of the Commission will be the best warrant the Government can have, that the inquiries of the Commission, both as to their nature and the manner of conducting them, will be pursued with discretion and a careful eye to avoiding impertinent and offensive interference with the legal authority and official rights of any of the bureaus with which it may be brought in contact.

"The Commission proposes a practical inquiry into the material of the volunteer force, with reference to the laws and usages of the several states in the matter of inspection, with the hope of assimilating their regulations with those of the army proper, alike in the appointment of medical and other officers, and in the rigorous application of just rules and principles to recruiting and inspection laws. This inquiry would exhaust every topic pertaining to the original material of the army, considered as a subject of sanitary and medical care.

"The Commission would inquire with scientific thoroughness into the subject of diet, cooking, cooks, clothing, tents, camping grounds, transports, transitory depôts with their exposures, camp police, with reference to settling the question how far the regulations of the army proper are or can be practically carried out among the volunteer regiments, and what changes or modifications are desirable from their peculiar character and circumstances? Everything appertaining to outfit, cleanliness, precautions against damp, cold, heat, malaria, infection; crude, unvaried, or ill-cooked food, and an irregular or careless regimental commissariat, would fall under this head.

"The Commission would inquire into the organization of military hospitals, general and regimental; the precise regulations and routine through which the services of the patriotic women of the country may be made available as nurses; the nature and sufficiency of hospital supplies; the method of obtaining and regulating all other extra and unbought supplies contributing to the comfort of the sick; the question of ambulances and field service, and of extra medical aid; and whatever else relates to the care, relief, or cure of the sick and wounded—their investigations being guided by the highest and latest medical and military experience, and carefully adapted to the nature and wants of our immediate army, and its peculiar origin and circumstances."

Careful as were the delegates in guarding against any possible interference with the Medical Bureaus and other departments of the army, and notwithstanding they declared in advance, that all the operations of the proposed Commission would be carried on from first to last at its own proper expense, the Government hesitated. The opinions then entertained at Washington, that inconvenience in some unforeseen manner might arise from such an organization, produced an unfavourable impression in administrative circles; whilst President Lincoln characterized the projected commission, in the worst joke he ever made, as nothing more nor less than a fifth wheel to a coach. But the pressure from outside, in other words, from the whole body of

the people, was too strong to be resisted. The inconvenience of the situation was too grave, the Medical Bureau too small and inexperienced to grapple with the threatened crisis, and the War Department finally consented to the authorization of the body—an authorization limited to these two duties, inquiry into the sanitary condition of the troops, and advice to the medical and kindred bureaus of the army upon the amelioration or cure of abuses. When this authorization of the Secretary of War was submitted to the President for his approval, Mr. Lincoln endorsed it with the very suggestive proviso—"The Commission will exist until the Secretary of War shall otherwise direct, unless sooner dissolved by its own action."

Having thus acquired the right to exist, to inquire and advise—temporarily though it were and on sufferance—it might be supposed that the Commission had surmounted the ordeal of birth, and could now address itself to the duties devolving upon it. But a newly appointed Surgeon-General viewed the organization with distrust. He declared his intention "to have nothing to do with it; that if it went into operation the responsibility must not rest upon him; and that it was a perilous conception to allow any such outside body to come into being." The officer in question was past the prime of life; his experience had not educated him to grapple with the colossal and unheard-of difficulties now threatening the army; he introduced no reforms into the bureau, and steadily maintained time-honoured abuses—abuses comparatively innocuous in an army of 15,000 men which occasionally saw bush-fighting on the frontier, but certain to be magnified a hundred-fold in the struggle on which the country was entering. It was manifestly necessary to reform the medical department of the army from the Surgeon-General to the youngest officer in the service, and the Sanitary Commission addressed itself to the task. The country soon understood and appreciated the organization and purpose of the Commission, so rapidly indeed, that within a few months of its existence the Commission had come to mean the whole medical profession of the North outside the army, and the entire body of the people who wished well to the soldiers, and desired to increase their comfort and efficiency. The Commission could therefore act with something akin to national authority, and it determined as one of its first duties to reform the medical department of the army, so as to render it competent to deal with the new phase in the army's requirements. Under its auspices a bill was drawn up in the executive committee of the Commission, introduced into Congress, carried by large majorities through both houses of the National Legislature, and finally endorsed by the President himself. A main feature of the new law was the appointment of six Inspectors-General; but the principal reform there inaugurated was one which many in Europe will perhaps regard as radical, if not revolutionary, namely, the substitution of capability for the time-honoured rule of seniority. It is no part of my duty to defend this reform. I am well aware that such an improvement, if improvement it be, may open the door to official favouritism, and, on the other hand, lead to injustice towards old and competent officers; but I may be permitted to assert that the reform in question has worked well in the United

States. Under the new Medical Act, a simple assistant-surgeon leaped over the heads of many seniors—a rise in grade from first lieutenant to Brigadier-General, relinquishing the control of a single hospital for the supervision of the medical necessities of half a million men. The Sanitary Commission which had inaugurated the new condition of affairs in the Medical Bureau suggested the nomination of this officer to the President, and was the cause of his confirmation by the senate, and the judgment of the Commission in the selection of Dr. William A. Hammond has been endorsed by the whole country, and commended by many of the leading medical organs of Great Britain and the continent of Europe. Perhaps the best indorsement of the soundness of the reform initiated by the Sanitary Commission, so far as the United States are concerned, lies in the fact of capability having since been substituted for seniority in the army itself. The change worked so beneficially in the medical department that the rule was subsequently applied elsewhere, Congress empowering the President to give command in the military departments to any officer he should select, without regard to seniority.

The official warrant for the organization of the Sanitary Commission was issued on the 9th of June, 1861, three weeks after the presentation of their first memorial to the Secretary of War by the New York delegates. The members of the Commission then appointed by the Government, nearly all of whom are still engaged in the duty, forthwith commenced a preliminary tour of inspection over an area as large as half the continent of Europe. Naturally enough, the inspection was not provocative of satisfaction. Scores of thousands of men newly drawn from civil life were huddled together in camp or barracks in defiance of all known sanitary requirements; the vast majority of their officers knew as little of drill and discipline as the men themselves; the surgeons found themselves in presence of new forms of disease, without experience to guide or remedies obtainable. From the banks of the Potomac, the swamps of the South, the prairie lands of the West, came the same refrain to the head-quarters of the Commission—"The first sanitary requirement of all is stern, unrelenting military discipline." And the Commission forthwith memorialized the Government in the following emphatic language:—

"The Sanitary Commission, in their endeavours to promote temperance, cleanliness and comfort among the troops, have become convinced that the first sanitary law in camp and among soldiers is *military* discipline, and that unless this is vigorously asserted and enforced it is useless to attempt and impossible to effect by any secondary means the great end they propose, which is the health and happiness of the army. Looking only to the health and comfort of the troops, it is our profound conviction that any special relaxation of military discipline in favour of volunteer troops, based either upon their supposed unwillingness or inability to endure it, or upon the alleged expectation of the public, is a fallacious policy, and fraught with peril to the lives of the men and the success of the national cause; and that, speaking in the name of the families and the communities from which the volunteers come, and in the name of humanity and religion, we implore that the

most thorough system of military discipline be carried out with the officers and men of the volunteer force, as the first and essential condition of their health, comfort, and morality."

Frequently during the war has the Sanitary Commission given similar advice to the Government on subjects which might seem to be entirely foreign to its organization; but it must not be forgotten that the association, while using the plea of humanity with the people, was compelled to adopt the tone of increased soldierly efficiency with the military authorities as the reason for its own existence. It has learnt, in fine, to yoke humanity with war; and, by depriving the latter of many of its accustomed horrors, has increased the efficiency of the army, and thereby strengthened the hands of the Government.

The first and principal duty of the Commission—sanitary inspection —was commenced, as already seen, immediately upon the authorization of the body by the Government. At the outbreak of the war, that is to say, during the summer of 1861, the Northern armies were in serious danger from epidemic disease. Modern sanitary science was hardly recognized in the regulations of the Medical Bureau, and its officers could not be expected to go beyond the strict line of official duty when that duty was more than quadrupled. The first business of the Commission, therefore, was to awaken general attention to the sanitary interests of the army, and to suggest improvements in the condition of camps, quarters, hospitals, and the men themselves. It sent out medical inspectors forthwith to warn inexperienced officers of the peril to which filth, bad ventilation, and bad food exposed their commands. It brought to bear upon the Government the influence of the medical profession throughout the country, effected the extension and invigoration of the Medical Bureau, and secured the express recognition of the *prevention* of disease, no less than its *cure*, as among the functions of the medical staff. The United States' Government now employs its own sanitary inspectors, and performs a certain portion of the preventive work effected by the Commission alone during the first year of its existence. But the Commission still keeps up an inspectorial *corps* auxiliary to that of the Government, for the latter is numerically unequal to its work, and there are special causes besides, which frequently interfere with its full efficiency.

Each inspector of the Commission, on visiting a camp or post, puts himself in the first place in communication with the military authorities, and asks their co-operation. This being secured, he proceeds to investigate the condition of the men in every particular that bears on their liability to disease, and the sufficiency of the remedial agencies within their reach. He inquires into the quality of their water supply, food, cooking, and clothing; the ventilation and cleanliness of their camp or quarters; the position of their latrines; the provision for the removal and destruction of refuse or offal; the equipment of their field or post hospital; their ambulance service; the competency of their medical officers; the salubrity or otherwise of their camp-site or post; the sufficiency of their bedding and blankets; the character of the diseases that have prevailed among them, and the precautions thereby indicated.

On these points he advises the medical and military authorities as a sanitary expert. His inspection, generally, discloses something that can be done to promote the health of the command. He finds, for instance, that tendencies to malarious disease exist, calling for quinine as a prophylactic; or scorbutic taints, requiring supplies of fresh vegetables; or deficiency of stimulants, bedding, articles of hospital diet, or disinfecting materials. If the want, whatever it is, can be promptly supplied through the regular official channels, he sees that it is done; but if it cannot, or if, as frequently is the case, something is required which Government does not undertake to supply, he calls upon the Relief Department of the Commission, which supplies it according to its ability. If the officer who should obtain it, be inexperienced in requisitions and supply-tables, the inspector is able to assist him. If the defect arise from corruption or incapacity, he reports the fact. It sometimes happens that the health of a camp is endangered by want, not of supplies, but of some work for which authority cannot at once be obtained. In such case, money is appropriated by the Standing Committee, or, in case of emergency, by the Associate Secretary, on the inspector's report. The Commission has done much work of this class. It has improved the ventilation of hospitals (Dr. Reid, formerly in charge of the ventilation at the Houses of Parliament, was at the head of this branch of the Commission's work at the period of his decease, two years ago), it has sunk wells to improve the water-supply of camps, built temporary hospitals and quarters to replace unwholesome and dangerous buildings, furnished and fitted up hospital transports, and converted ordinary railway carriages into railway ambulances, with cooking apparatus and store-rooms, and litters hung on springs, in which thousands of men, with fractured limbs, have travelled hundreds of miles without avoidable suffering or injury.

The results of every inspection are noted on blanks provided for the purpose, and are severally reported. Each report covers about two hundred distinct points affecting the sanitary condition and wants of the force inspected. More than 2,000 of these reports have been accumulated. These are digested and tabulated as received, by a competent actuary; and it is believed that the body of military and medical statistics thus collected, is among the largest and most valuable in existence. Surely such a work cannot fail to furnish conclusions of the utmost importance to sanitary science.

The Commission employs other agencies for the prevention of disease. It has furnished material for the vaccination of thousands of men at a time, now happily past, when the Medical Bureau was unable to supply the tenth part of what was needed, and only issued what it had, after a fortnight's delay. It has thus stayed the ravages of small-pox in regiments crowded on board transports, after that disease had actually begun to spread amongst the men. During the first year of the war, all classes of "eruptive disease" in one of our most important military departments, were consigned indiscriminately to a single hospital, from which men were "discharged cured" of mumps or measles, and rejoined their regiments to sicken and die of the small-pox contracted in this "hospital," so called, and to infect and kill their

comrades. It was through the persevering remonstrance and protest of the Commission that this abuse was at last corrected.

The Commission has also circulated throughout the army, and especially among the medical staff, many hundred thousand of its medical documents. This series now numbers eighteen publications, each devoted to some special point of prevention or cure. Some of them are addressed to the individual soldier, but the great majority are for the use of the medical staff, and relate to the prevention or treatment of the diseases to which camps are specially exposed, and to sundry operations of military surgery with which it cannot be expected that surgeons recently appointed from civil life should be generally familiar. These monographs have been prepared specially, at the request of the Commission, by some of the most eminent physicians and surgeons in the country. The list comprises the following treatises :—

An Introductory Paper on the employment of Anæsthetics in military surgery.

Report on Military Hygiene and Therapeutics.

Directions to Army Surgeons on Fields of Battle.

Rules for preserving the Health of the Soldier.

Report on the use of Quinine as a Prophylactic.

Vaccination in Armies.

Report on Amputations.

Report on Amputations through the Foot, and at the Ankle Joint.

Venereal Diseases, with special reference to practice in the Army and Navy.

Reports on—

Pneumonia.

Continued Fevers.

Excision of Joints for Traumatic cause.

Dysentery.

Scurvy.

Nature and treatment of Fractures in military surgery.

Nature and treatment of Miasmatic Fever.

Nature and Treatment of Yellow Fever.

Hemorrhage from wounds.

Control and prevention of Infectious Diseases in camps, transports, and hospitals.

It is proper to mention here that the Medical Bureau of the army has liberally supplied the surgeons with a well assorted library of medical works; but these monographs of the Commission are considered indispensable to the staff, and are sought for with avidity by the surgeons. I have the honour to request your acceptance, Mr. President, of a few copies of a work containing those monographs, edited in its present form by Dr. Hammond, the late surgeon-general, under the auspices of the Commission. Many surgeons of her Majesty's army and navy have expressed to me their unqualified approval of these essays, and I have, therefore, some justification for believing that the work will not prove unacceptable or useless. There are two

other classes of publications edited and distributed, in most instances gratis, by the Commission; one intended for the troops themselves, and calculated to amuse and instruct at the same time, the other for the benefit of the people at large, reporting at short periodical intervals the labours, wants, and condition of the people's almoner—the Commission. Millions, literally, of these documents have been issued broadcast during the war. As agent of the Commission in England, I have had the pleasure to circulate myself upwards of 10,000 copies in this country, for the Association I represent has understood from the outset that its labours are not confined to America alone, but are designed to benefit humanity and relieve suffering everywhere.

The Commission institutes special inspections also, from time to time, outside of its general inspection system. It employs medical agents to look into the condition of such camps or hospitals as seem to require special attention, and to ascertain and report the wants of the different armies during or immediately after a trying campaign. It has lately made a thorough inspection of all military hospitals throughout our vast extent of territory, employing for this purpose medical practitioners of the highest professional standing. Their recommendations of improvement in our hospital system, and its administration, have been submitted to the proper authorities, and in nearly every instance promptly acted upon.

From the nature of the case, it is impossible to estimate with accuracy how many men have been saved from disease or death by these labours of the Commission, nor to calculate how much efficiency has been economized to the service by this one branch of prevention, for, though the results of the treatment of disease can be more or less accurately recorded, the result of preventive measures cannot be stated with any kind of certainty. The only attainable data are the per centage of disease among men to whom such preventive measures have been applied, and among those to whom they have not. Though inferences from comparison of the two are not absolutely to be relied on, a comparison of the mortality rates of the American army with those of others may perhaps throw some light on the subject.

While the French army in 1528 was preparing to besiege the forts protecting Baiæ, it was almost totally destroyed by malarious disease. Of 28,000 men, only 4,000 remained alive, and they were helpless. The region around Baiæ is certainly not worse than some of the malarious districts of the United States, as, for instance, the swamps of the Tennessee, Mississippi, and Chickahominy, the Everglades of Florida, and the sea islands of South Carolina, yet, nevertheless, native born Americans and foreigners from every country in Europe live in those districts with comparative freedom from disease. The explanation lies in the fact that sanitary science is at present studied and understood, the medical practitioner aiming at prevention rather than cure.

The average annual loss of the whole British army during the Peninsular War was 165 men out of every thousand; but of these 165, 113 died by disease or from accident. From 1803 to 1812 the annual average death-rate of the British army "abroad" was 80 per thousand, 71 by disease, and only 9 from wounds received in action. In the

Burmese War the loss was 35 per thousand from wounds, whilst from sickness it rose to the terrible figure of 450 per thousand.

In July, August, and September, 1854, the British army lost at the rate of 293 men out of 1,000 per annum. 96 per cent. of this loss was from disease. During the next three months, October, November, and December, 1854, the loss was at the annual rate of 511 out of every thousand, seven-eighths of which were from disease. In January, 1855, it was at the rate of 1,174 per thousand per annum, 97 per cent. of the whole loss being due to disease alone. Who can describe the horrors of Varna? Dr. Aitkin says: "My estimates lead to the conclusion that the amount of sickness at Varna was greater than that of the French army in Spain, and nearly as great as the army of Portugal while engaged in active campaigns, and this, too, though not a soldier in Lord Raglan's army had fired a shot. From October, 1854, to April, 1855, six months, the army of 23,775 men lost 9,248 by sickness, and only 608 by wounds. In the last six months of the Crimean campaign, including the final assaults which carried Sebastopol, the French had 21,957 men wounded, and 101,128 cases of sickness.

Up to May 18th, 1862, that is to say, during a period of about twelve months of actual campaigning, the United States' armies lost at the rate of 53 men per thousand per annum, and only 44 per cent. of that loss was by disease and accident. The report of the Secretary of War in 1864 states the number of patients in the general hospitals up to June 30, 1863, as 9·1 per cent., and in field hospitals 4·4 per cent. of the whole national force, numbering upwards of half a million men. Of this aggregate of 13·5 per cent., 11 per cent. were due to sickness, and 2·5 to wounds and other casualties.

Such a gratifying result can only be explained by the marked attention paid to sanitary requirements, and the stringent but beneficent discipline which has enforced the teachings of science, for it must be borne in mind that the armies of the United States were peculiarly liable to the ravages of disease, in a far higher ratio assuredly than the armies of European nations. The American people, prior to this war, were remarkably non-military. Out-of-door pursuits were little in vogue, as with Englishmen; the vast majority of the officers were as ignorant of their duties as the privates themselves; the Southern States, so far as regarded military areas and strategic points, were as unhealthy, to say the least, as any portions of the European continent, whilst sanitary science, as applicable to armies, had to be taught from its very rudiments. What has been accomplished is due, in a great measure, to the Sanitary Commission—*directly*, by its own recommendations to the officers and men themselves; *indirectly*, by the influence it has brought to bear upon the Government in making *prevention* a part of medical duty as well as *cure*.

I have thus far sketched the operations of the Commission in the first part of its labours—namely, inquiry as to the health, comfort and efficiency of the troops, and advice in reference to their improvement. These two questions may be considered to form the whole duty of such bodies, but the Sanitary Commission of the United States has gone far beyond mere inquiry and advice. Its chapter of "Relief" is one of

the brightest in its history. The honour of the initiation of this department is due to the women; and the movement on their part was general and almost simultaneous throughout the North at the very commencement of the war. But this important branch of the Commission's labours only reached its present development after much experience and reflection. Until it was known what the troops might want, and the Government could not immediately supply, many things would be overlooked which now seem to be absolutely necessary. What appeared to be immediately required was offered without delay, the first record of direct relief being the tender to the Government of 100 trained female nurses. The advisers of the women, however, became satisfied from their visit to Washington that enormous and frequent calls for help would be made upon the benevolent; and the Commission anticipated the threatening crisis by appeals to the citizens at large, and especially to the great moneyed corporations, such as insurance and banking companies. The appeal was not made in vain. Contributions flowed in from all quarters, and the first necessities of the troops were attended to without delay, but not in a degree equal to the increasing demand for help. The most pressing want of the Commission was *system*. Examples of the system requisite, were nowhere forthcoming, for the work was new, and the system could only be taught by hard experience. Independent agencies of relief existed throughout the various Northern States, organized expressly to aid the volunteers from particular localities. This system, if system it may be called, was simply a perpetuation of the principle for which the rebellious States were contending, but against which the North protested. I shall avoid political questions as thoroughly as possible in my remarks, but am compelled to refer to them in this one instance in order to show what the Sanitary Commission has accomplished in behalf of the Federal authority and the cause of the North. The Commission broke down these State lines, ignored the dogma of separate State sovereignty, and merged the whole body of the citizens into one people. This was effected by volunteer agency alone, without assistance from Government or the National Legislature. The president of the Commission, Dr. Bellows and his subordinates, proved to the people of the various States that the army must be treated as a solid, indivisible body, not as an aggregate of independent integers; they made plain to them that it was well nigh impossible to follow individual regiments or battalions over the vast area of the war, except by dealing with them as parts of a national body; and, that could their design be effected, the expense of transportation and distribution would be enormous, and ultimately ruinous. One by one the hundreds of local and State "Soldiers' Aid Societies" throughout the North attached themselves to the United States' Commission; but there still remained an immense proportion of the citizens, especially the women, who laboured independently of any organization whatever. The Commission undertook the *rôle* of disciplinarian, or schoolmaster, to these well-intentioned but short-sighted people, and ultimately attached the greater proportion to its ranks. Order succeeded to disorder, the mind of the country became disciplined, and this Volunteer Commission, by the simple forces of expediency and

reason, systematised the benevolence of the whole nation. Some remarks of Dr. Bellows on this question will not be out of place. In dealing with the objections to official routine which many people in America, as in England, take pleasure in gainsaying under the name of "Red Tape," he spoke as follows:—

"I know nothing more foolish and insane than that universal popular cry against 'red tape.' Permit me to say that in the army 'red tape' is as essential to men as white tape is at home to women. I need not say it is an equal folly to attempt to do without the one as to do without the other. Instead of decrying 'red tape,' all my experience has taught me to believe that the principal difficulties connected with the humane administration of army affairs are due to the neglect of 'red tape.' If you could have real 'red tape,' not that kind painted on barbers' poles, which ties up nothing—if you could only have real rule, method, and habit, carried out to the death even, you would have the surest way of attaining to the best results in military affairs. And that is a matter that ought to be more generally understood among the women and men in the land. The women—God bless them—think that it requires nothing but a good and loving heart to aid the poor soldier; but I can assure you, that however ardent, and warm the heart, its pulsations, to be effective, must be regulated by order and method."

The Relief Department, as now organized, consists of two branches —"General" and "Special," each possessing its distinct executive and staff, both surbordinate to the Executive and Standing Committees of the Commission. *General relief* is given in the form of hospital supplies and sanitary stores to the general and field hospitals, and to regimental hospitals and armies in the field. The *special relief* branch deals with needy and sick soldiers in the vicinity of military depôts, and with men accepting furlough or discharged from the service. It is also given with equal liberality to prisoners of war and paroled men, and to individual cases of special suffering wherever found among soldiers, for which the army regulations do not provide. Finally, the sick and wounded are assisted in other modes than those above enumerated, their friends and relatives being likewise aided by the Hospital Directory and other agencies.

Under these organizations every camp and military hospital, from the Atlantic to the plains beyond the Mississippi, is regularly and frequently visited, its wants ascertained, anticipated as far as possible, and, whenever needed, supplied immediately by the Commission to the full extent of its ability. For the means of maintaining the necessary organization, and of exercising through it a direct influence upon the officers and men, the Commission is wholly dependant upon voluntary contributions. It is the same in respect to all the various articles, whether of food, clothing, medicines, hospital furniture, &c., supplied by it to the army, for it has received no pecuniary aid whatever from the Government.

It must not be supposed that the Medical Department of the army has in any way relaxed its efforts on account of the labours of this Commission, or that the medical requirements of the soldiers are less

carefully attended to by the American Government than is found amongst other nations. The articles of medicines, hospital furniture, food, delicacies, &c., are as diversified and numerous in the American Army Regulations as those of any European army; and that refuge of the surgeon at critical periods—the Hospital Fund—is thoroughly well organized and amply supplied. The regular army ration daily served to the troops consists of the following items and quantities:—

$\frac{3}{4}$ lb. pork, *or* $1\frac{1}{4}$ lb. fresh beef.
18 oz. biscuit, *or* 20 oz. soft bread or flour.
1-10th lb. coffee.
1-6th lb. sugar.
1-10th lb. rice, *or*
1-10th lb. beans or hominy.

Besides

Fresh or dessicated vegetables, molasses and vinegar, supplied at intervals during the week.

Very few men could consume the whole of such a ration as the above. What remains over is returned to the commissary-sergeant of the regiment by the Captains of the different Companies; the value in money goes to increase the Regimental Hospital Fund, and is used to purchase comforts and delicacies for the sick and wounded at the option of the surgeon.

The Medical Staff acts in the *rear* of the army. The Sanitary Commission's relief system operates in the *front*, and, in addition, supplements the Medical Staff in its labours *as a reserve*. Medical Staffs are constituted to deal with the ordinary requirements of military life, whether in time of peace or during campaigns; they are organized in view of averages of wounds, sickness, or accidents, and the most efficient of them will, in times of emergency, find greater demands upon its attention than it can supply. The American surgeons have found this to be most emphatically the case during the present war. An unexpected and rapid movement of an army has occasionally left the entire hospital-train far away in the rear; or a general advance after a sanguinary engagement has deprived the various regiments of most, if not all, their medical officers and attendants, who were left on the field with the wounded. On these occasions, the surgeons and trained agents of the Commission have supplied, as far as possible, the places of the absent surgeons, drawing upon the Commission's stores for everything required by the new list of sufferers. The following extract from the Commission's official report of its labours during and after the battle of Gettysburgh, will show how such relief is furnished:—

"When the enemy (under General Lee) was known to have crossed the Potomac in force, responsible and experienced officers of the Commission were stationed at Harrisburg, Philadelphia, Baltimore, and Frederick, and a systematic daily communication was established between the agents moving with the different columns of the army and the central office of the Commission. Supplies were accumulated and held ready for movement at different points on the circumference of the seat of war, and care was taken to have ample reserves at the branch

offices, ready for shipment. With the first news of the battle at Gettysburgh, Westminster, the nearest point of railroad communication with the battle-field, was fixed upon as the point of approach, and authority to run a car daily with the Government trains was obtained.

"Two waggon-loads of battle-field supplies had been distributed to meet deficiencies in the stores of the surgeons, shortly before the battle commenced. These waggons returned to Frederick for loads, and two others, fully loaded, arrived from Frederick at the moment of the assault of Longstreet upon the left wing of the loyal army, and were driven under fire to reach the collections of wounded in its rear. As one of them came to a point where several hundred sufferers had been taken from the ambulances and laid upon the ground behind a barn and in an orchard, less than a thousand yards in the rear of our line of battle, then fiercely engaged, a surgeon was seen to throw up his arms, exclaiming, 'There is the Sanitary Commission, now we shall be able to do something.' He had exhausted nearly all his supplies; and the brandy, beef-soup, sponges, chloroform, lint, and bandages, which were at once furnished to him, were undoubtedly the means of saving many lives.

"Supplies having arrived at Westminster before the close of the battle, a school-house, centrally situated among the *corps* hospitals, was taken as a field depôt, to which they were brought as speedily as possible by the three remaining waggons then on the ground, and from which they were rapidly distributed where most needed. Eleven waggon-loads of special supplies were here distributed to the *corps* hospitals, and to scattering groups of wounded found on the field, before any supplies arrived by railroad. Additional means of transportation were at length procured from the country people, of whom also some stores were purchased, and a station was opened in the town of Gettysburgh. On the 6th, the branch railroad to Gettysburgh, which had been broken up by the enemy, was so far repaired as to allow a train to approach within a mile of the town. By the first train which came over it after the battle, two car loads of most valuable goods were sent by the Commission, and two or more went by each succeeding train for a week. The wounded now began to be brought from the field to the railroad for removal to fixed hospitals elsewhere. As they arrived much faster than they could be taken away, they were laid on the ground exposed to the rain, or to the direct rays of the sun, *without food.* This having been anticipated and provided for by the Commission's agents in Baltimore, on the second day of the battle the Commission had a complete relief station, on a large scale, in operation at the temporary terminus of the railroad. It consisted of several tents and awnings, with a kitchen and other conveniences. In the meantime, the movements of the army and the prospect of another great battle on the Potomac, demanded the attention of the Commission. Six new waggons with horses were procured in Baltimore and Washington and sent to Frederick, to which point also supplies were forwarded by rail and thence transferred by waggons to Boonsboro', where a house was taken and a depôt established on the same day that Boonsboro' was occupied by General Meade. A house for a depôt was also secured at

Hagerstown as soon as the enemy retired from it. Supplies were at the same time sent by rail down the Cumberland Valley, with waggons and horses for their further carriage, procured in Philadelphia."

Immediately the news of the battle reached the North, the agents of the Commission dispatched surgeons engaged for the occasion to the scene of hostilities. As in every other instance, the surgeons, on their arrival, reported themselves for duty, with their assistants and nurses, to the army medical officers. Some idea of the amount of work gone through at Gettysburgh may be formed when it is recollected that upwards of 20,000 wounded men remained on the field at the close of the battle. The Commission dispatched no less than 60 tons of perishable articles to the scene of action, stowed in refrigerating waggons. The following list of articles given away on the occasion by the Commission, *to friend and foe alike without distinction*, may be interesting:—

Clothing, &c.

Drawers, woollen	5,310 prs.	Oil-silk	300 yards
" cotton	1,833 "	Tin basins and cups	7,000
Shirts, woollen	7,158	Oil-linen and bandages	110 brls.
" cotton	3,266	Water tanks	7
Pillows	2,114	Water coolers	46
Pillow cases	264	Bay rum and Eau de Cologne	225 bots.
Bed-sacks	1,630	Fans	3,500
Blankets	1,007	Chloride of lime	11 brls.
Sheets	274	Shoes and slippers	4,000 prs.
Wrappers	508	Crutches	1,200
Handkerchiefs	2,659	Lanthorns	180
Stockings, woollen	3,560 prs.	Candles	350 lbs.
" cotton	2,558 "	Canvas	300 yds.
Bed utensils	728	Mosquito-netting	648 pieces
Towels and napkins	10,000	Paper	237 quires
Sponges	2,300	Pants, coats, hats	189 pieces
Combs	1,500	Plaster	16 rolls.
Buckets	200		
Soap, Castile	250 lbs.		

Food, &c.

Poultry and mutton	11,000 lbs.	Ice	20,000 lbs.
Butter	6,430 "	Concentrated beef soup	3,800 "
Eggs	8,500 doz.	" milk	12,500 "
Garden vegetables	675 bush.	Prepared farina	7,000 "
Berries	48 "	Dried fruit	3,500 "
Bread	12,900 lvs.	Jellies	2,000 jars
Tamarinds	750 gals.	Preserved fish	3,600 lbs.
Lemons	116 box.	Pickles	400 gals.
Oranges	46 "	Tobacco	100 lbs.
Coffee	850 lbs.	Tobacco pipes	1,000
Chocolate	831 "	Indian meal	1,621 lbs.
Tea	426 "	Starch	1,074 "
White sugar	6,800 "	Cod fish	3,848 "
Syrups	785 bots.	Canned fruit	582 cans
Brandy	1,250 "	" oysters	72 "
Whisky	1,168 "	Brandy peaches	303 jars
Wine	1,148 "	Catsup	43 "
Ale	600 gals.	Vinegar	24 bots.
Biscuit, rusks, &c.	134 bar.	Jam ginger	43 jars.
Preserved meats	500 lbs.		

The estimated value of these articles was, in round numbers, 75,000 dollars, or £15,000 sterling, but there was a great additional outlay for kitchens, sleeping quarters, shelters, &c., constructed on the field. The battle of Gettysburgh is no exceptional instance in the Commission's record, and must be taken simply as a sample of what is performed, in an equal or less degree, by the Commission whenever and wherever an engagement takes place.

In the single military department of the West, that is to say, to the armies of the Tennessee and the Cumberland, now forming the commands of Generals Sherman and Thomas, articles similar to the above were supplied by the Commission during the two years preceding September 1st, 1863, to the value of 2,250,000 dollars and upwards—£450,000 in English currency. The Department of Virginia made still greater claims upon this Volunteer Association, whilst steady and continuous streams of benevolence are flowing from the same source to New Orleans, Savannah, Arkansas, and the Rio Grande, wherever, in fine, there are troops holding posts or engaged in campaigning.

The operations of the Commission in respect to anti-scorbutic vegetables are deserving of attentive study. Next to *malaria*, there is nothing so calculated to diminish the efficiency of troops as scurvy, and it is probable that most of the ailments affecting armies are nothing more nor less than types of this insidious and little understood disease. The attention of the Commission was first called to this subject by the condition of the Western armies, and it acted with such promptitude in the emergency, by purchasing vegetables in the Western markets, that those articles immediately rose to an unprecedented figure as a consequence. It soon understood, however, that it would not do to depend upon the markets alone, and it established vegetable gardens in various parts of the country, appointed special cultivators at its own expense, and supplied them with all the necessaries of agriculture, such as tools, seeds, and manure. I will again cite one army as a sample of the rest, and quote from a letter written by the general treasurer of the Commission. In speaking of the army of the Potomac in front of Petersburg, he writes as follows last July:

"There are, of course, signs of a scorbutic taint diffused throughout the army, and the Commission is doing everything to check its progress. I am satisfied that the operations of the Commission in this one direction will exercise an appreciable influence on the result of the campaign, and that they are equivalent to reinforcement by an additional army corps. It seems certain that the daily issue of 50,000 lbs. (70,000 rations last Friday) of anti-scorbutic vegetables, pickles, lemons, onions, tomatoes, &c., to the men themselves, in the trenches and elsewhere, must have a considerable effect in keeping down tendency to disease, and economising the efficiency of the army. We keep 40 four-horse waggons of our own constantly moving between City Point and the front; and we have five steamers running constantly between City Point and Washington, Philadelphia, Baltimore, and New York, for transportation of these stores."

While on the subject of anti-scorbutics, I would seek your attention, Mr. Chairman, to the article on "Scurvy" in this volume of medical

pamphlets published by the Commission. It is from the pen of Dr. Hammond, the late surgeon-general of our army; and several eminent physicians and surgeons in England have spoken of it in high terms of commendation.

In all articles furnished by the Commission, the utmost caution is exercised. Instructions are given to the different agents to divide and distribute as fairly as possible, the most needy being first and liberally dealt with. Care is likewise taken that no army officer, medical, or otherwise, shall be relieved from responsibility in securing for those dependent upon him all that he ought to obtain directly of the Government. For every dollar's worth issued at the numerous depôts controlled by the Commission, vouchers are signed by the surgeon or his assistant, and countersigned by the Commission's inspectors, who have previously ascertained that the supplies are actually needed.

The vast majority of the contributions from the people are necessarily in kind, especially in respect to clothing. The system by which these goods are obtained may be likened to the economy of the human body. Villages around towns pour in their offerings to the latter; these again forward the goods in bulk to the principal cities of districts, the great centres like New York, Washington, Cairo, or Cincinnati making requisitions upon them for whatever may be needed. The electric telegraph binds the whole to the head-quarters of the Commission, well represented by the heart, and this again pours out a steady stream of supply to the various armies and bodies of troops in every part of the country. It is, in fact, similar to the vein and artery system of our bodies.

The cash receipts of the Commission, from its establishment to the 1st of October last year, amounted to 3,083,124 dollars, or about £620,000 sterling, reckoning five dollars to the pound. Of this amount five-sixths were expended up to the same date in the purchase of medicines, food, &c., and in distributing articles of all kinds to the army. The "supply department," which has for its work the collecting, storing, forwarding, and distributing of supplies, together with the relief service, requires the labour of a permanent *corps* of employés, averaging 200 men. There are other bureaus, as, for instance, the department of medical inspection, or "inquiry and advice," by which, for nearly four years, a series of inspections has been kept up by scientific men in the general and field hospitals, and the different regiments. There are also the bureaus of "special relief," the "hospital directory," "statistics," and "publication." The appraised value of articles in kind received by the Commission to October, 1864, was 8,406,272 dollars. The Commission owns its horses, waggons, harness, barges, store-houses, tents, and hires its own transports, yet the entire cost of distribution was only 410,455 dollars, *or* 4·88 *per centum of the value of the supplies distributed over an area half as large as the continent of Europe.* Previous to July 1st, 1864, the cost of distribution over the entire country was but 3·76 of the value of the supplies, but the ratio was greatly increased during the subsequent three months by the necessity of chartering steamers and vessels for carrying anti-scorbutic vegetables to the army of the Potomac. 2,250,000 dollars' worth of

supplies were distributed to the Western Department in the two years ending September 1st, 1863, at an entire cost of only $1\frac{1}{2}$ per centum upon the valuation. The Commission makes it a rule to pay all its *employés*, believing that work to be well done must be paid for, but the members of the executive committee, 22 in number, who have the entire responsibility of everything resting upon them, give all their time and services gratis.

The field relief and ambulance corps, forming a distinct branch, is charged with certain duties on the march, and during action. Its place is absolutely in the front, and it has constantly advanced with storming parties at such assaults as those on Forts Wagner and McAllister on the Ogeechee and Fort Fisher. At the close of the action it hunts up the wounded, carries them to the rear, treats them surgically when the regular surgeons are too occupied, and carries the exhausted and suffering to the temporary lodges of the Commission, where they may obtain food and shelter.

The department of Special Relief was established at an early period of the war, and has grown to be one of the most important of all, requiring a special executive and a very large corps of trained assistants. Its objects are the following:—

1. To supply to the sick men of the newly-arrived regiments such medicines, food, and care as it is impossible for them to receive in the midst of the confusion, and with the unavoidable lack of facilities, from their own officers. The men to be thus aided are those who are not so sick as to have a claim upon a general hospital, and yet need immediate care to guard them against serious sickness.
2. To furnish suitable food, lodging, care, and assistance to men who are honourably discharged from service, sent from general hospitals, or from their regiments; but who are often delayed a day or more in the city, sometimes many days, before they obtain their papers and pay.
3. To communicate with distant regiments in behalf of discharged men, whose certificates of disability or descriptive lists on which to draw their pay prove to be defective; the invalid soldiers in the meantime being cared for, and not exposed to the fatigue and risk of going in person to their regiments to have their papers corrected.
4. To act as the unpaid agent or attorney of discharged soldiers, who are too feeble or too utterly disabled to present their own claims at the paymaster's office.
5. To look into the condition of discharged men who assume to be without means to pay the expense of going to their homes, and to furnish the necessary means where we find the man is true and the need real.
6. To secure disabled soldiers railway and other tickets at reduced rates; and, through an agent at the railroad and other stations, to see that these men are not robbed or imposed upon by sharpers.
7. To see that all men who are discharged and paid off, do at once leave the city for their homes; or in cases where they have been

induced by evil companions to remain behind, to endeavour to rescue them, and see them started with through tickets to their own towns.

8. To make reasonably clean and comfortable, before they leave the city, such discharged men as are deficient in cleanliness and clothes.
9. To be prepared to meet at once, with food or other aid, such immediate necessities as arise when sick men arrive in the city in large number from battle-fields or distant hospitals.
10. To keep a watchful eye upon all soldiers who are out of hospitals yet not in service, and give information to the proper authorities of such soldiers as seem endeavouring to avoid duty, or to desert from the ranks.

The "Soldiers' Homes" connected with this branch, are established at various points in the neighbourhood of the armies, and, literally, millions of meals and nights' lodging have been given gratis to the soldiers by their means. There are twenty-two of these Special Relief Stations in the North and West. During the first thirty months of the war 121,047 nights' lodging, in clean beds, were given to passing soldiers in the single city of Washington, while 359,816 men sat down to table in addition to many thousand meals distributed in steamboats and railway trains. "Nurses' Houses" are set apart for the benefit of the nurses of the Army and Commission when not actually engaged in duty; and crowds of soldiers' relatives, from different sections of the country, have also been entertained in them temporarily.

One of the best forms of Special Relief is that furnished by the "Hospital Directory," a regular record of the name, regiment, state, complaint, condition, &c., of every soldier in all the military hospitals of the country. Upwards of a million names are now inscribed on its pages, and no fee whatever is exacted for information. The entire operations of the Commission, from first to last, are administered without fee or reward.

I have thus sketched, though only in a rapid and cursory manner, the salient points of the Commission's work. The best of all arguments in its favour is to be found in the orders of American Generals in reference to it, the emphatic approval of the army and navy surgeons—for a goodly portion of its supplies is furnished to that branch of the service—and its popularity with the troops themselves. Its work is absolutely Samaritan, and has obtained the warm approval of the Confederate surgeons and military authorities; but whilst recognising the philanthropy of its labours, it must not be forgotten that the reason of the Commission's existence, and the cause of its support by the nation at large, are due to its increasing the strength and efficiency of the national forces. The Sanitary Commission of the United States' Army has educated the people to the requirements of the war, and forced the entire nation to interest itself in the well-being of the soldier. The army has been a *lever* resting on a *fulcrum*—the Government at Washington; but the women, and children, and men in the far away homes of the North have been the *power* manœuvring the *lever*. The Sanitary Commission has, in fine, disciplined and instructed the whole

people, and enlisted every man, woman, and child in the military service of the country.

The CHAIRMAN: Gentlemen, it is only at our Evening Meetings that discussions are allowed; consequently, on the present occasion, I am sorry to say, no questions can be asked, nor any observations made which would give rise to discussion. It is our custom, however, upon these occasions to thank the Lecturer for his kindness, and if any gentleman present is inclined to move that vote of thanks, it will give an opportunity for expressing his opinions upon the general subject of the paper, which I think is one of the most important that, to my knowledge, has ever been brought under our notice within the walls of this theatre.

Sir HARRY VERNEY, Bart, M.P.: Mr. Chairman, I take the liberty of profiting by the permission which you have given, to propose a vote of thanks to Mr. Fisher for the very interesting lecture which he has been so good as to communicate to us. Before I go further, I will say that I shall take the earliest opportunity of informing Miss Nightingale of the notice which Mr. Fisher has taken of her labours. I know that they have been instrumental in forwarding the cause of humanity in the armies of the United States. This is a kind of rivalry in which all of us can with great joy and satisfaction unite, viz., who shall be the first in the cause of humanity? who shall do the most to prevent the horrors of war afflicting more than is absolutely necessary those who are exposed to them? and in endeavouring, as far as possible, to communicate to each other all the information we are able to obtain, so that the armies of each nation may benefit by the experience of the other. We Englishmen must feel gratified to know that the cause of humanity in the armies of the Federals and the Confederates has been advanced by our own experience in the Crimean and other wars; and if we in return are enabled to benefit by the experience now being gained by the Army Sanitary Commission in the United States, I am sure it will be a source of satisfaction to us, as it will be to our brethren in America. The points upon which the Lecturer has touched are most interesting and important. I cannot help hoping that the lecture, which has been so eloquent, and communicated in such an interesting way, may be printed, so that we all may derive the fullest benefit from it. It seems to me a pity, when a lecture is read in this Institution, the details of which we can only remember very cursorily, that we should not have the opportunity of studying it at our leisure, and gathering from it all the lessons which the information contained is calculated to convey to us. Therefore, I venture to hope that Mr. Fisher will consent to the lecture being printed. With regard to the extraordinary fact of the benefit of sanitary arrangements, I am reminded of that which is probably known to the Lecturer, that the mortality of our Guards has diminished from fifteen per thousand to seven per thousand in the course of a very few years, in consequence of the sanitary arrangements that have been carried out in the army. And whereas our army in the Crimea lost more men, probably, than any army we ever sent abroad, I believe it is the fact that our army in the last expedition to China lost less; indeed, I have been assured that the

health of our army while in China was better than the health of the same number of men in this country. That result I believe to be entirely owing to the admirable sanitary arrangements which are now carried out and which were adopted in consequence of the disasters that we suffered in the Crimean war. Those who desire the welfare of our army must, I am sure, wish that those disasters should be ever present to our minds; for I confess I should view with great regret any relaxation of the efforts which have been made to improve the sanitary condition of the soldier. My firm conviction is that there is no subject to which the attention of Parliament is given with greater satisfaction and greater earnestness, than that of providing for the welfare of our soldiers and sailors. I believe there is no course more economically wise, even if we were to put the matter upon that low principle, the saving of money, than to take every measure by which the health and welfare of our soldiers and sailors may be promoted, so as to make them what they ought to be, models of good health and good conduct. For my part I shall never be satisfied with regard to the character of our sailors and soldiers, until I hear of an old soldier or an old sailor returning to his native village the best conducted man there, and being welcomed by his neighbours as the most valuable acquisition that can be brought into their community. A great deal has been done in that direction, but a great deal more remains to be done; and I believe, by the exertions of those who are at present at the head of our army and navy carrying into effect the wishes of the country upon the subject, that much more will be effected. I take the liberty of proposing that we return our sincere thanks to Mr. Fisher, and I beg to assure him that we heartily desire to express our good will to that great country from which he comes; and our earnest hope that the present war which now afflicts the country may cease, and that the inhabitants of America, as well as of our country, may remain on the best terms and cultivate the arts of peace.

The Chairman: Sir Harry Verney has mentioned the advantages which will arise from the printing of Mr. Fisher's paper, and to these I may add my belief that it will be of considerable interest abroad, where so much attention has been given to the subject, particularly at Geneva. M. Henri Dunant has written a work entitled "Un Souvenir de Solferino," a very touching book, which must be very well known to many gentlemen present. M. Dunant originated the meeting in that city which gave rise to the "*Conférence Internationale de Genève pour étudier les moyens de pourvoir à l'insuffisance du service sanitaire dans les armées en campagne.*" The documents connected with this movement have been sent to this Institution, and are now in the library, and since the announcement of the present lecture, one or two foreign newspapers have been sent to me containing articles upon the subject. I only regret that they have not been put into the hands of some gentleman more competent to speak upon the subject. The papers allude to the nationalisation of the hospitals of armies in the field. This, among others, was the object of the meeting at Geneva. Many of the powers of Europe have given their adhesion to the proposal. The Emperor of

the French especially did so, and I have been told that within the last fortnight the Government of this country has done the same. For this there exists a very good precedent, because it will be in the minds of many present, that at the battle of Dettingen, George II. confided to the Duc de Noailles his wounded, and subsequently Lord Stair, in writing to the Duc de Noailles to say that he had liberated the whole of the French prisoners, thanked the Duke for the care that had been taken of the English wounded, saying, "Such generosity softens the rigours of war, and does honour to humanity." This appears to have given rise to a treaty between Lord Stair and the Duc de Noailles. I believe in the Seven Years' War a similar treaty existed. I have taken the liberty of mentioning these instances, because they appear to be of much interest. I only regret that the supplementing by voluntary aid, the sanitary service of armies in the field, will not be introduced at an evening meeting, to afford an opportunity for the discussion of that subject. I will conclude by reverting for a moment to the war of the Austrian Succession. I believe it was upon that occasion that Prince Eugène said that 100,000 men would be a better guarantee than 100,000 treaties. We now have an exception to this rule, for I think one treaty in favour of humanity will be more efficacious than the force of 100,000 men. I have now the pleasing duty to perform, of conveying to Mr. Fisher the thanks of this meeting for a most important and a most interesting lecture.

Mr. Fisher: Allow me to thank you, in the first place, for your friendly feeling in asking me to lecture on the subject. As a stranger, and yet not a stranger, for I trust that we in America feel that we are one with you, I must say that I feel honoured on behalf of the United States' Sanitary Commission by the courtesy which has been extended to me by the invitation to lecture here; and I feel greatly honoured by your kindness in listening so attentively, and deeply gratified by the endorsement that you have put, not on American work, but on humanitarian work. In the name of common humanity, I tender you my thanks.

LECTURE.

Friday, February 24th, 1865.

GENERAL SIR JOHN FOX BURGOYNE, Bart., G.C.B., R.E., Director of Works, in the Chair.

THE EMPLOYMENT OF ELECTRICITY IN MILITARY OPERATIONS.

By Captain H. SCHAW, R.E., Professor of Fortification and Artillery, Royal Staff College, Sandhurst.

IT is now nearly two years since I first undertook, at the request of the Council of this Institution, to give a lecture on Electricity as applied to Military purposes. Owing to various causes, the lecture has been deferred, and it is a proof of the rapid progress of the age that the facts which I shall now have to bring before you differ in some material points from those which I should have spoken of two years ago. New instruments have been invented, new discoveries made, and our knowledge of the subject has advanced so far, that electricity, which, but a few years since was looked upon as a philosopher's plaything, may now be fairly classed amongst the exact sciences.

So subtle is this force, however, so varied in its manifestations, so difficult to isolate from the influences of surrounding objects and forces, that some electrical phenomena are still but imperfectly understood, and an entirely satisfactory theory of electrical science has not yet appeared. Our instruments also, both for electrical measurements and for making use of electricity in practical operations, are in most instances still susceptible of improvement; and it is most essential that in the applications of electricity to military purposes, as in every other branch of military science, our army should keep pace with the discoveries and improvements of the day, and should be watchful, and ready to seize upon and weave into the web of that great and complicated fabric, the modern military system of civilised nations, every new scientific discovery which can be made to minister to the art of being the strongest.

The four special applications of electricity to war purposes to which I intend to draw your attention are—

1. The ignition of gunpowder.
2. The electric telegraph.
3. The electro-ballistic pendulum.
4. The electric light.

Electrical science has various other useful military applications, such as the *protection* of ships of war, and powder magazines, and other military buildings *from the effects of lightning* by means of the improved system of lightning conductors, for which the country is indebted chiefly to the researches of Sir Snow Harris; and the multiplication of copper plate engravings by an *electro-metallurgical* operation, which has been largely used on the Ordnance Survey. But such applications of electrical knowledge being in no way peculiar to the army, I will not allude to them further.

A safe, ready, and certain method of igniting gunpowder is of great value in numerous military operations. The circumstances under which it may be necessary to effect the ignition may be classed under two general heads. The ordinary service and proof of ordnance may be considered as one special branch; military mines as the other branch. Without alluding to small arms, we may be well satisfied with the friction-tube, as answering all the requirements of the artillerist, except in the case of the proof of ordnance, when for safety the operator must be at a distance, and electricity is advantageously employed. In this case there is a uniformity in the circumstances, and therefore a corresponding uniformity in the mode of operation, which may readily be reduced to a system.

The ordinary means of exploding mines, viz., "powder-hose" and "Bickford's fuze," cannot be considered as either safe or certain, and electricity may in most cases take their place with great advantage; but in mining operations the circumstances vary very widely, hence the adoption of one system becomes more difficult than in the former case.

For instance, *the powder* may be in one charge or divided into a number of charges. It may be buried deeply under ground or under the water, or it may be placed in blast holes, or with but slight covering in buildings, to be hastily destroyed.

It may be necessary to operate from a great distance, or the electrical apparatus and operator may be placed in safety within a comparatively short distance of the mines.

In some cases the *simultaneous* explosion of a number of mines is of importance; and sometimes in this case the failure of one or two charges may be of little detriment.

In other cases it may be most essential to the success of some operation that one or two, or, it may be, a larger number of charges, should explode *without fail*, and probably at a particular moment.

There are cases again in which the miner may choose his own time for the explosion, and others in which the exact moment of ignition must be dependent on the uncertain movements of the enemy against whom the mine is directed.

Numerous other variations in position, number, time of explosion, and comparative values of certainty and facility in the operation, will occur, and a method of igniting gunpowder which is perfectly satisfactory in

all cases has not been discovered up to this time. While admitting this however, I must claim for electricity (whatever defects may still exist in our methods of applying it) that it is generally the most safe, certain, and convenient mode of exploding mines; and the only method by which we can ensure the perfectly simultaneous explosion of a number of mines, or the ignition of gunpowder at a distance at any particular moment, more particularly under water or in wet situations.

In confirmation of this, I may mention that at the commencement of the late demolition of the fortifications at Corfu, the electrical apparatus not having arrived from England, powder-hose was used for exploding the mines, and although every care was used, a number of the mines missed or hung fire; the latter description of failure being the more dangerous, as the fire sometimes smouldered for a quarter of an hour, and the mine exploded quite unexpectedly; moreover, perfectly simultaneous explosions could not be satisfactorily accomplished.

After the arrival of the electrical apparatus, the degree of certainty in the explosion of the mines was very greatly increased (amounting practically to perfect certainty in the case of the voltaic battery) the risk of hanging fire was entirely removed, and absolutely simultaneous explosions were effected without difficulty.

Before describing the apparatus by means of which sufficient heat for firing gunpowder may be produced by electricity, it will be necessary for me to put briefly before you the elementary principles of electrical science as now generally received. Electricity is now looked upon as one of the manifestations of the great force pervading all creation, which we call the attraction of gravitation, and of which mechanical force, heat, electricity, and chemical affinity, are but different modes of development, any one of which may be converted into any one of the others by proper treatment. Without attempting to define what this force with so many "*aliases*" may be, we know electricity, by certain accompanying phenomena, in two states, *at rest* and *in motion*, or static and dynamic electricity. A body statically electrified may be considered as having either more or less electricity than the earth, which is the electrical zero, just as with regard to heat the temperature of our bodies is our zero, and we speak of other bodies feeling cold or hot as they have less or more heat than our bodies, so a body is said to be positively or negatively electrified when it has more or less electricity than the earth.

And just as when two bodies at different temperatures are connected by a substance which will conduct heat, that which has most heat parts with its superfluity to that which has least. So if two bodies unequally electrified be connected by a substance which will conduct electricity, a flow or *current* of electricity passes from that which has most to that which has least, in the way which we call dynamic electricity.

The force compelling this transfer of electricity is generally known as *electro-motive force*, and it is greater or less in proportion to the amount of difference in the electrical states of the two bodies which are connected by the conductor.

All bodies with which we are acquainted, oppose resistance to this transfer of electricity, but the degrees of resistance offered by different

bodies are so very various that for convenience they are classed under two different heads—bodies which resist but feebly the electrical current, such as the metals, are termed conductors, while those possessing the property of resisting very strongly the passage of electricity, such as glass and resin, are termed insulators.

To understand rightly the action of electricity, we must have clear ideas of what are meant by the four terms—

Electro-motive force,
Electrical resistance,
Electric current, and
Quantity of electricity.

Electro-motive force is the active force tending to restore equilibrium when it has been disturbed, by causing the transfer of electricity, and overcoming the resistance opposed to this transfer.

Electrical resistance is what its name implies, the opposition or resistance offered by the substance through which the transfer of electricity takes place, diminishing the strength of the current, or the quantity of electricity which passes per second.

Electric current is the result of electro-motive force overcoming resistance, and we may generally reason about an electric current much in the same way as we do about a current of water.

We speak of *quantity of electricity* in the same way as of a quantity of heat stored in a body—*e.g.*, the heat stored in a red-hot 32-pounder shot is a definite quantity, which would do a definite amount of work, such as converting so much water into steam, and producing so much mechanical force. So a definite quantity of electricity stored in a Leyden jar will do a definite amount of work in passing out of it in the form of a current or of a spark, by decomposing so much water, or producing a definite amount of heat.

A committee appointed by the British Association has been engaged for some time past in deciding upon certain standards for electrical measurements.

The unit of resistance has now been decided upon, with reference to the acknowledged units of mass, time, and space, and material standards of resistance may be procured, taking the place of the yard measure of length, in all electrical measurements. Standards of *electro-motive force, current*, and *quantity*, have also been provisionally decided upon; so that electrical measurements may now be made by proper instruments with as much accuracy as measurements of heat, or of weight, or of length, breadth, and thickness.

Let us now pass in review the electrical effects which are practically useful in military operations.

1st. The earth is a magnet; a peculiar ore of iron known as the lode-stone possesses the same property; soft iron brought in contact with the lode-stone becomes temporarily a magnet, and steel permanently so. The north end of one magnet attracts the south end of another, and repels its north end, and *vice versâ*, from which it will be evident that the end of a magnet which points towards the north pole of the earth is in itself a south pole, and not a north pole, as we are in the habit of calling it.

2nd. Soft iron may be temporarily, and steel permanently magnetized, by the action of a current of electricity. If a wire be insulated and wound round a bar of soft iron, a current of electricity passed through it will instantaneously convert the soft iron into a magnet, and it parts with its magnetism as instantly on the cessation of the current. Electro-magnets are used in the majority of electrical instruments.

3rd. A spiral of wire carrying a current of electricity is itself a magnet, and will act on a magnet balanced inside it, attracting and repelling its opposite poles, so as to cause it to deflect from its normal position. An instrument made on this principle is known as a galvanometer, and is used for detecting and measuring currents of electricity, and also for needle telegraphs.

4th. As currents of electricity produce magnetism, so from magnets (either permanent or electro-magnets) currents of electricity may be produced. From a permanent magnet it is most easily produced by an arrangement devised by Professor Wheatstone. Soft iron bars wound with insulated wire are fixed on the poles of a permanent magnet of a horse-shoe shape, a soft iron armature is pivoted so as to revolve in close proximity to the ends of the soft iron bars without touching them ; at the instant when this armature recedes from the ends of the bars a momentary current of electricity passes through the coils of wire in one direction, and at the moment when it approaches the poles again, another instantaneous current circulates in the opposite direction. Thus by rapid rotation of the axis a constant succession of alternate currents is produced.

From an electro-magnet a similar succession of alternate currents might be produced in the same way by mechanical means. It is more usually obtained by a different arrangement: a bundle of soft iron wires is wound, first with a thick insulated wire, through which the current from a voltaic battery is made to pass, converting the system into a powerful magnet—a fine insulated wire is wound over the primary thick wire on the cylinder, and an ingenious arrangement of the circuit connecting the primary wire with the battery causes an alternate breaking and reforming of this connection with great rapidity. At each breaking and making of contact, a momentary current passes through the outer thin wire. Such an instrument is known as an induction coil. It is probable, however, that more powerful currents would be obtained by the mechanical arrangement than by the more usual and ingenious form of the instrument, in which the current does its own work, and uses part of its power in breaking and making contact.

This principle has been used in instruments for igniting gunpowder, for producing the electric light, and for telegraphing, as will be mentioned shortly.

5th. An electric current produces heat.

6th. An electric spark produces heat, or more properly, it is the manifestation of the heat produced by the sudden passage of a quantity of electricity through a highly resisting substance.

These two last effects are practically used in the ignition of gunpowder, we must therefore consider them first.

*Here is a voltaic battery, each cell of which has an electro-motive

* The lecturer exhibited a battery of Grove's construction, having ten cells.

force, equivalent to nearly two standard units. The accumulated electro-motive force of the 10 cells, we may call 20, *i.e.*, the platinum pole has an electro-motive force of 10+, or above the zero of the earth, and the zinc pole has an electro-motive force of 10−, or below the zero of the earth.

But each cell of the battery has also a certain resistance, which we may call $\frac{1}{10}$ of a unit of resistance, or the whole battery has a resistance equal to 1. When the poles of the battery are not connected, this electro-motive force does no work, being unable to overcome the resistance of the air between the poles; but if the poles are connected by a wire of metal, a constant current of electricity passes through it and the battery. If the wire be thick, and of a metal which has a low specific resistance, but little apparent effect will be produced on the wire, but there will be a large consumption of zinc in the battery. If the wire be thin, and of a metal which has a high specific resistance, the electro-motive force, in overcoming this resistance and forcing a certain quantity of electricity through the circuit, will raise the temperature of the wire, doing work in that part of the circuit; at the same time, consumption of zinc in the battery will be less. This principle is made use of for the explosion of gunpowder—a very thin platinum wire is introduced into the charge to be exploded; thick copper wires lead to the voltaic battery at the moment when the circuit is completed, the platinum wire is raised in temperature to the fusing point, and the gunpowder is ignited.

Now the exact force necessary to ignite the gunpowder in this way, can be readily determined; by a few simple experiments the electro-motive force and resistance of one cell of the voltaic battery can be found, and the electrical resistances of the conducting wire per yard, and of the platinum wire in the fuse can also be easily measured, as also the current required to fuse the platinum wire.

The celebrated law of the German philosopher Ohm, then enables us to determine how many cells of the battery will be necessary in any given case.

The law is $C = \frac{E}{R}$ or the current is proportional to the electro-motive force directly, and to the resistance inversely.

Suppose we find, by experiment, that our platinum wire is fused when the electro-motive force is 1, and the total resistance in the circuit is 1 unit, then $C = \frac{E}{1}$ represents our normal current. To produce this same current when the resistance is increased by the addition of conducting wire, or fuses, in the circuit, we must add more cells. For instance, let conducting wire of resistance equal to 2 units be added (about 200 yards)

Then $\frac{E}{1} = \frac{N \times E}{N \times (\frac{1}{10} + 2 + 1)}$

Whence $n = 3\frac{1}{3}$

That is three cells would not produce fusion, but four would do so. In practice we should use five or six to overcome accidental defects.

Without going further into such calculations, it may be stated briefly that the best mode of connecting any number of charges with a battery,

as well as the power necessary in any particular case, may readily be determined. There are three general methods of connecting a number of charges with a voltaic battery to produce simultaneous explosion.

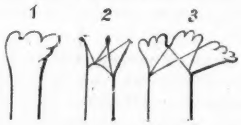


Fig 1, the continuous circuit. Fig. 2, the divided circuit. The first is the simplest, and is suited to a large number of small cells, which is a troublesome battery; the second, the most certain, and is suited to a few large cells; but a large number of mines cannot be exploded thus. Fig. 3 shows a combination of the two systems, which is the best for a large number of mines. Twenty-one were thus fired simultaneously in the demolition of the Keep at Corfu.

If instead of ten cells of this battery I had some hundred cells, the electro-motive force would be so great that if I were to approach one pole incautiously I should receive a violent shock; or a spark would pass between a conductor connected with one pole and brought near to the other pole. A similar effect may be produced by other means, viz., by friction, or by magnetic induction. Both of these means have been tried, and friction, though until lately uncertain in its results, has now, through the wise adoption of a new material, viz., *hardened* india-rubber or *ebonite*, by Major Von Ebner, of the Austrian army, been found by far the most powerful and certain means of producing heat by electrical spark.

Formerly electrical machines were made of glass, which is a very hygrometric substance, and allows the deposition of a thin film of water over its surface very readily when the air is at all damp. Glass is a good insulator, but water is a conductor. Thus, machines for developing electricity by friction when made of glass, will not act in a damp atmosphere, as the electricity escapes over the surface as soon as it is developed. But ebonite, a more perfect insulator than glass, is also eminently non-hygrometric, and by substituting plates of this substance for the old glass plates, or cylinder, of the electrical machine, and sheets of vulcanized india-rubber and tin-foil rolled up into a cylinder for the old glass Leyden jar, a compact and portable instrument has been produced, which is perfectly efficient in the wettest weather.

By means of this instrument, and a very delicate fuse, invented by Professor Abel, as many as fifty mines may be exploded simultaneously, in one continuous circuit. I believe that the number of fuses successfully ignited at one discharge has even reached the high number of 150. The fuse is, however, a very important part of the apparatus. The electric spark will not generally ignite dry gunpowder, but simply knocks the grains away. It is necessary, therefore, to interpose in the circuit a substance offering a certain amount of resistance to the passage of electricity, not too much nor yet too little, and this substance should be readily inflammable. Fulminate of mercury has

been successfully used; but the best material yet discovered is that used by Professor Abel, a mixture of subphosphide of copper, subsulphide of copper, and chlorate of potassa. This compound possesses all the necessary properties, when carefully prepared, and kept from atmospheric influences. Like all such chemical compositions, however, it is liable to deterioration.

A rapid succession of electric sparks may be obtained from electro-magnets arranged as induction coils, as before explained, or from permanent magnets, arranged on Professor Wheatstone's plan. Wheatstone's magnetic exploder is a very convenient and portable instrument, but not nearly so powerful as the frictional machine for the ignition of gunpowder.

The induction coil, if well made, is very powerful; but it is more delicate, troublesome, and expensive than the frictional machine.

It will be seen, then, that there are two general methods of igniting gunpowder by electricity, viz., 1st by the direct current of a voltaic battery heating a thin platinum wire; 2nd, by the electric spark obtained from a friction machine (or by induction from magnets), acting upon a chemically prepared fuse. It remains to compare these two systems, and to note their excellencies and defects.

1. *The Direct Current.*—Experience has shown that this method is very certain, as certain, in fact, as it is possible for anything human to be, if the proper precautions be taken in testing before hand, and during the operations of preparing the mines, every part of the circuit, including the battery. Such tests can readily be applied as will give perfect certainty, that the electrical circuits are perfect, and that the electric current is sufficient to do the work required of it. The only element of uncertainty is, in moist situations, the danger of the powder becoming wet. This is a mechanical difficulty which, by proper care, ought seldom to cause a failure.

The conducting wires require to be perfect as regards conductivity, *i.e.*, that the resistance of the circuit should not exceed its proper amount, but insulation is of comparatively small moment. Now resistance is easily tested, and a little care will ensure that its proper amount shall not be exceeded. But tests for insulation are more difficult and delicate, and it is by no means easy to repair defects in insulation, which are very liable to occur from rough usage, or from deterioration of the insulating material by exposure to heat, light, and air.

The fuse can be made by any tinsmith, if the platinum wire be obtainable; and thin iron wire will supply its place on an emergency.

This method, then, is *certain;* and the apparatus and stores connected with it are not liable to deterioration, and thus efficiency can always be tested and ensured.

On the other hand, the batteries are troublesome and not very portable, and mines cannot be exploded at any considerable distance from the battery, by this means, without using an inconveniently large number of cells, which would also be necessary to explode more than from twenty to twenty-four mines simultaneously.

2nd. *The Electric Spark.*—Of the methods of igniting gunpowder by the electric spark, the most satisfactory is the friction-machine. It may

be taken, then, as the type, and its excellencies and defects apply, more or less, to the other two instruments. Its advantages are simplicity and portability; it is always ready for use, requiring only occasional re-amalgamation of the cushions. It is efficient at great distances from the mines to be exploded, and the number of mines which can be exploded simultaneously is fully double that which the voltaic battery can conveniently command. It requires but one conducting wire, and the connections with the mines are always the same, and as simple as possible. On the other hand, the fuses which must be used with this instrument are delicate, and liable to deteriorate by keeping, and they cannot be extemporised or improved when defective, nor have we, at present, any satisfactory test which will discover whether a fuse is good or not. Professor Abel is now engaged in the endeavour to discover such a test; and should he succeed in doing so, of which he is very sanguine, the only serious objection to the exclusive use of this method will have been removed.

The necessity of perfectly insulating the conducting wire, although perfect insulation is a condition more difficult to ensure than perfect conductivity, is nevertheless a minor disadvantage; and the other advantages of this system over that of the direct current from the voltaic battery heating platinum wire are so great, that were the element of uncertainty which now is connected with the fuses, and the impossibility of testing removed, it would be so far superior to the other as to leave no room for comparison. As it is, however, the superior certainty of the voltaic battery and platinum wire fuse gives it a decided advantage in cases where certainty of explosion is of more importance than convenience. Under other circumstances, however, which are of frequent occurrence, when the occasional failure of a fuse is of slight importance, the frictional machine or magnetic exploder with Abel's fuse are much to be preferred to the old system. In the proof of ordnance this is eminently the case, and probably the magnetic exploder is the most suitable instrument for this purpose.

We will now pass on to consider the electric telegraph in its applications to war purposes.

Its first military application was a light submarine cable from Varna across the Black Sea, to complete the telegraphic communication between England and our army in the Crimea, and a system of telegraphic communication between Balaklava, Kasatch, and the different divisions of the British army there. During the Indian mutiny the electric telegraph was of essential service to our army. The late Lieut.-Colonel Stewart, of the Engineers, had charge of this department, and, with great energy, carried on the telegraphic wire always with the advance of the Commander-in-Chief, enabling him to keep up constant communication with the seat of government. The French made use of the telegraphs of the country in the late war in Italy, repairing them when destroyed by the Austrians, and using them to keep up communication along their line of operations with their base. In America, both North and South have used the electric telegraph largely, and some amusing anecdotes have reached us of tapping the enemy's telegraph wire, and so obtaining information which was not at all intended for the person who received it.

An electric telegraph equipment and a corps of telegraphists now form an integral part of nearly every European army, and of the American armies. In our own service, the duties connected with the electric telegraph have hitherto been entrusted to the corps of Royal Engineers, and a provisional equipment is now in course of formation and trial at Aldershot. The officers of Engineers are taught at Chatham the principles and practice of electric telegraphy, and the various tests and electric measurements required in such operations. A certain proportion of non-commissioned officers and sappers are taught to manipulate the instruments, and to perform all the mechanical operations connected with repairing the instruments and batteries, and the construction and maintenance of telegraphic lines.

The electric telegraph in its military application has three general developments—

1. It may be stationary, connecting the various forts of a large fortified position, such as those at Portsmouth and Plymouth, or the various works of such fortresses as those of Malta and Gibraltar.

2. Or it may be moveable and of comparatively short length, to connect corps d'armée with head-quarters, and outposts during the marchings and manœuvres of a campaign.

3. Or it may be an extensive line of telegraph, maintaining the communications of an army with its base of operations during an advance, often consisting of the telegraphs of the country repaired, sometimes of a special line put up in a somewhat permanent manner as the army advances.

Intermediate between these is the case of the telegraphic communications in a standing camp, such as those at the siege of Sebastopol.

In stationary military telegraphs the conductors are sometimes buried under ground, sometimes suspended in the air. The latter plan is generally preferable, because defects are easily discovered and easily repaired.

In special cases it may be necessary to bury the wire underground, and the depth should be sufficient to avoid risk of injury from shells (five feet probably would be sufficient). Such underground systems are very expensive, and very difficult to repair when accidental faults occur.

Moveable Electric Telegraph lines may either consist of an insulated wire laid along the fences by the roadside, as it is unwound from drums carried in a waggon—the system pursued in America, as I am informed by Captain Beaumont, R.E., who was for some time with General M'Clellan's army—or it may be a thin bare wire, supported on light poles or lances, carried by men at intervals of about 40 or 50 yards, which is the system adopted in the Austrian and Prussian services.

The former appears to be the best, as it requires fewer men. It would be desirable if the insulated conductor could be protected by an outer sheathing, so as to be secure against accidental injury from wheels or horses' hoofs; but the extra weight and expense of such a conductor are great objections to its use. An ordinary copper wire of several strands, equivalent altogether to one of 16 or 18 guage, insulated with gutta-percha or india-rubber, and protected with tarred hemp, appears the most suitable upon the whole.

For the third class of military telegraphs a bare iron wire supported on poles must generally be adopted; for single lines of moderate length insulators are not essential, and were not used in India; but they are of advantage, especially during rains and fogs. Generally it would seem desirable to have a few hundred miles of No. 8 iron wire, with insulators and tools, and materials necessary for erecting a line of this sort on poles at the base of operations of an army, and about ten miles of insulated wire with the head-quarters, to be used as a moveable conductor.

The electric telegraph instrument, which appears to me best suited for military telegraphs, is the ordinary single needle instrument, used very generally in England. It is cheap, portable, simple, easily repaired, it requires but feeble currents of electricity to work it, and ordinary clerks can transmit messages at the rate of about 12 words a minute by its means.

The Morse telegraph instrument is more perfect than the single needle. It records the messages sent, is less liable to error, and greater speed is attainable by its means. It is, however, more costly, less portable, requires more powerful currents of electricity, and is not so readily repaired as the single needle. I think, therefore, that it should be only used in special cases on long lines of comparative permanency.

These instruments both require voltaic batteries to set them in action, and probably the battery used at the Royal Engineer establishment at Chatham is the most convenient arrangement.

It is a modification of Daniel's constant battery, the metals being copper and zinc, the copper being placed below the zinc in each cell, instead of beside it. Gravity keeps the heavier salt—sulphate of copper—at the bottom, and the lighter—sulphate of zinc—floats at the top; each metal is, therefore, immersed in a solution of a salt itself. No acids nor porous earthenware cells are required for this battery. Dry crystals of sulphate of copper, and water, are sufficient to charge it for use, and it will remain in action with occasional addition of crystals for about a year. The sulphate of zinc is rapidly formed by the action of the battery.

Telegraph instruments are made, to be worked without voltaic batteries, by the induced currents obtained from permanent magnets. These have some advantages on the score of convenience and portability, and of efficiency out of doors in frosty weather, when batteries are liable to freeze. Instruments of this class are sometimes made to signal by means of needles; sometimes in the same manner as the Morse instrument, and sometimes as dial instruments, showing the letters of the alphabet by a pointer on a circular face, like a clock. The last form may be occasionally useful in military telegraphs, as it requires less carefully trained operators, and is very portable. Probably the form manufactured by Messrs. Siemens and Halske is the strongest and best suited to military telegraphs. It is used in the Prussian and Austrian services.

The operators should evidently, in most cases, be soldiers, and a certain proportion of the whole of them should be capable of repairing any part of the apparatus which may get out of order, and of tracing out the cause and position of any ordinary fault in the line.

A certain amount of training is necessary for this purpose, and it seems desirable that men so far trained should be thoroughly educated in all the different modes of telegraphing, whether by Captain Bolton's light—by flags—or other means alluded to in lectures given lately in this Institution by Captain Bolton, 12th Regiment, and Captain Colomb, R.N., and that they should be constantly practised in these various modes of telegraphing.

Such a training is, as far as possible, given to the men of the Royal Engineers selected for this course at Chatham, and they are also instructed in the method of firing mines by electricity. Arrangements are also made to employ the trained men from time to time in this especial service. I fear, however, that the system is not as satisfactory as that pursued in most foreign armies, in which a special corps of telegraphists exists. It is one of the defects of a comparatively small army that men are too valuable to be given up entirely to one branch of what may be termed the scientific work of the army, and it follows that the scientific corps are as far as possible trained to perform a very great variety of duties. Now, excellence in every branch of industry has been obtained by division of labour, by giving each indvidual one definite work to do, when it may fairly be required that he shall do it thoroughly well. The contrary system has its advantages. It tends to give readiness of resource and fertility of invention. It expands the minds of those whose range of education is thus enlarged, and makes such soldiers less machines, more thinking men; but it is doubtful whether the work is so well performed under this system as under that of the division of labour.

I must pass on, however, to the two other applications of electricity I have mentioned.

The electro-ballistic pendulum, as now used at Shoeburyness, under the able management of Lieutenant Noble, R.A., is the invention of Major Navez, of the Belgian service, and it is a vast improvement on the cumbersome ballistic pendulum formerly in use. The object of the instruments being to ascertain the velocity of shot and shell at the moment of their leaving the mouth of the gun, and at different periods during their flight, and so to arrive at accurate conclusions with regard to the laws governing the motions of projectiles of various shapes, sizes, and weights, projected with different charges of powder, and at different angles of elevation, from ordnance of all descriptions. In these days of revolution in all artillery, such investigations have the highest practical value, and enable us to decide between competing systems of construction and service of ordnance, and to determine the direction in which experiment may be pursued advantageously with a degree of confidence otherwise unattainable. Without entering into the details of the construction and action of the apparatus, the principle of its action may be thus briefly described.

A small pendulum swings freely beside a graduated arc of a circle. carrying with it an index arm having a carrier on the end reading $\frac{1}{20}$th of a degree. The law of the motion of a pendulum is so exact that the *time* occupied by the pendulum in moving through the space of one of the smallest divisions of the arc is accurately known.

The pendulum is supported at one extremity of the arc by a straight electro-magnet, and the index can be clamped at any part of its path by a powerful horse-shoe electro-magnet.

Two open frame works of wood are erected in the range of the gun to be tried, at 40 feet apart, and a wire is wound backwards and forwards across each of them in such a manner that the shot in passing through each frame must cut the wires. The wire on this first frame is connected with a voltaic battery and the straight electro-magnet, so that while it is unbroken, the pendulum remains suspended at the upper zero point of the arc. When the gun is fired the shot cuts the wire and releases the pendulum, which instantly commences to travel down the graduated arc. The wire wound on the second frame is connected with another battery and electro-magnet, which latter, when it loses its power by the wire being severed by the shot's passage through the second frame, allows a weight to drop, and completes the circuit of the clamping horse-shoe magnet, and so arrests the index hand in its course. The number of degrees through which the pendulum has moved corresponds very nearly with the time occupied by the shot in moving through the 40 feet between the two frames. Various corrections are applied to this reading, by means of which the velocity of the shot can be determined within an extremely minute fraction of absolute exactness. It is evident that the frames may be placed at any point in the range at the proper height to allow the shot to pass through them in its flight, and so to record its own velocity at that particular part of its course.

There are two general applications of artificial light which are useful in war, *signalling* and *illuminating* an enemy's works. The first application has been ably treated of by Captains Colomb and Bolton, I will not, therefore, allude to it further. The power of illuminating an enemy's works at night is however an important auxiliary in war, whether offensive or defensive. In offensive warfare it has been successfully used by the Federal Americans. By means of the Drummond lime light, placed at a distance of nearly 1,000 yards from Fort Sumpter, they succeeded in illuminating the breach they had formed in the fort, so far as to enable them to discover working parties, and keep up a fire upon it at night and so prevent the Confederates from repairing it.

In the defence of a fortress such power of illuminating the besieger's works at night and discovering his working parties must retard the siege most materially, as it is chiefly at night that we can now hope to sap up towards a fortress well-garrisoned and armed with modern rifled small arms and ordnance.

There are two qualities necessary in a light to illuminate at a distance, *volume* and *penetrating power*. The electric light is very much more powerful than the lime light in the latter of these qualities, yet one of Serrin's ordinary electric lamps will not illuminate sufficiently to distinguish moving objects at a greater distance than about 400 or 500 yards.

It is probable, therefore, that a combination of a number of lime-light lamps was used by the Americans so as to produce a great volume of light, and that a combination of two or three ordinary electric lamps, or perhaps one having a greater volume of light than is usual, by means of

a more powerful current of electricity, might effect the purpose. Experiment is needed in this direction.

At present our means of illuminating enemies' works are light balls thrown by mortars, which, falling on the ground, illuminate the surrounding objects to a certain extent; their range of illumination is, however, very limited, especially if they fall into trenches or hollows in the ground into which they have a natural tendency to roll. Colonel Boxer has invented a very ingenious apparatus called the parachute light; it is enclosed in a paper case like a 13-inch shell which, when it is projected from a mortar, and has attained its full height, is made to burst open by a small charge of powder, exploded by a fuze. The light, which is very powerful, is ignited at the same moment and remains suspended in the air for some time by a sort of parachute which is folded up in the paper case and which opens out as the vessel containing the light-composition begins to fall.

There is some uncertainty connected with the use of either of these arrangements, and a light so powerful that, by means of proper moveable reflectors, the whole neighbourhood of a fortress may be swept by rays of light to a distance of from 500 to 1,000 yards, and all the night arrangements of an enemy detected, is a most valuable auxiliary to the defence. Such an arrangement is quite practicable though it has not yet been experimentally used. The necessary electric currents may be obtained either by voltaic batteries or from permanent magnets.

About fifty cells of a large voltaic battery of Bunsen's or Groves' pattern are required to produce a good light. To obtain a sufficiently powerful current from permanent magnets a small steam-engine would probably be required, although for signalling purposes a sufficient volume of light might be produced by a machine worked by manual labour.

The voltaic battery appears the most hopeful source of electricity in the defence or attack of fortresses, being more portable than the steam-engine and magnetic apparatus.

Until lately there was a great difficulty experienced in producing a steady electric light, but this difficulty was most ingeniously overcome by M. Foucault, and his ideas have been improved upon by Mr. Holmes in England, and by Messrs. Serrin and Dubosc in France.

The light is produced by a powerful current of electricity between two points of pure carbon, which at first are made to touch and are then separated to a short distance, when a brilliant arc of flame, consisting of minute particles of ignited carbon, is sustained between them. The carbon points are both gradually consumed, but the consumption of the point connected with one pole of the battery is more rapid than that of the other, and the steady brilliancy of the light is contingent upon the exact distance at which the maximum light is obtained, being preserved between the charcoal points. The problem to be solved therefore was to preserve the centre of the space between the points always opposite the centre of the reflector, while the points were kept at a constant distance from one another.

The details of the mechanism by which this has been effected differ

slightly in different electric lamps, but the general principle of their action is this—

An electro-magnet forms a part of the circuit of the current of electricity producing the light. The strength of a current, you will remember, is inversely proportional to the resistance opposed to it. In this case the resistance in the circuit increases as the charcoal points are consumed and the space between them increases. When from this cause the current is reduced below a certain point the electro-magnet so far loses its force that a spring, always acting in opposition to the magnet, withdraws a soft iron armature from it, and in so doing releases clockwork which is arranged so as to move the two points towards each other, but one more rapidly than the other. As they approach the resistance is diminished, the current becomes stronger, and the magnet again attracts its armature and stops the clockwork, and so on. This arrangement with various adjustments has now been rendered so perfect that the variations in the light due to the alternations in the strength of the current are imperceptible, and its brilliancy is practically constant.

The rays are all gathered and thrown in any desired direction by a reflector, which may be made paraboloidal if the rays are to be thrown parallel to one another, or hyperboloidal if they are to be slightly dispersed. For the defence of fortresses such lamps would no doubt be disposed behind iron shields, or in cupolas, throwing their rays of light through a small orifice, which it would be very difficult for an enemy to hit by his distant fire.

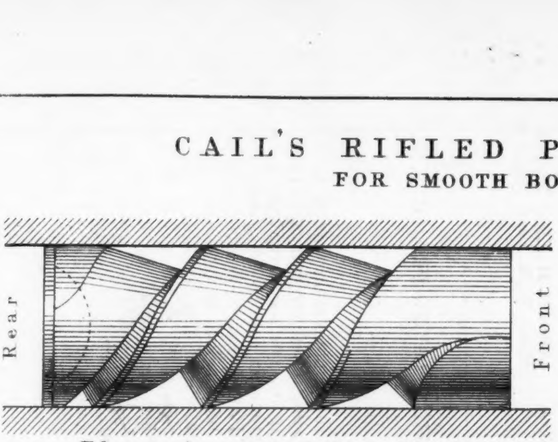
I have now brought before you, as fully as time would permit, the four principal military applications of electricity, viz., the ignition of gunpowder by electricity, the electric telegraph, the electro-ballistic pendulum, and the electric light; illustrating the conversion of the electric force into heat and light and mechanical force, and thus exemplifying the wonderful unity of the works of God in creation, and the immense variety in the modes of his working.

The peculiar advantage of this form of force is that it produces the required effects at a distance from the source, and instantaneously. Electricity cannot be economically employed to produce heat or mechanical forces near at hand; other more simple and ordinary means are in such cases either great in amount, or almost invariably superior to it; but when time and distance are to be overcome rather than great effects produced, the value of electricity is fully developed.

CAIL'S RIFLED P

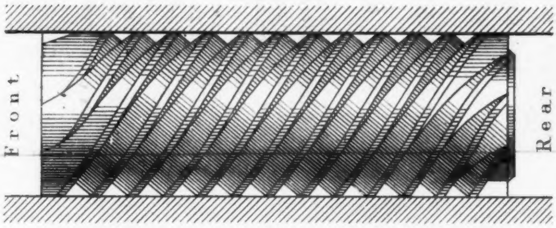
FOR SMOOTH BOR

Fig. 1.



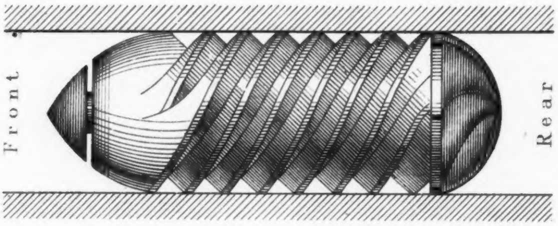
Elevation of Solid Shot.
3 Diam.[s]

Fig. 2.



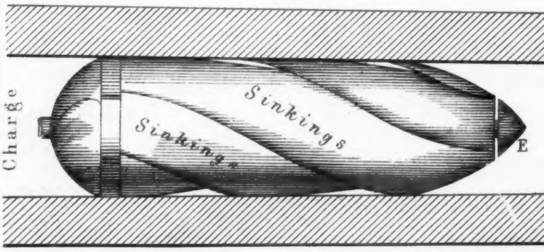
Elevation of Cylinder.

Fig. 3.



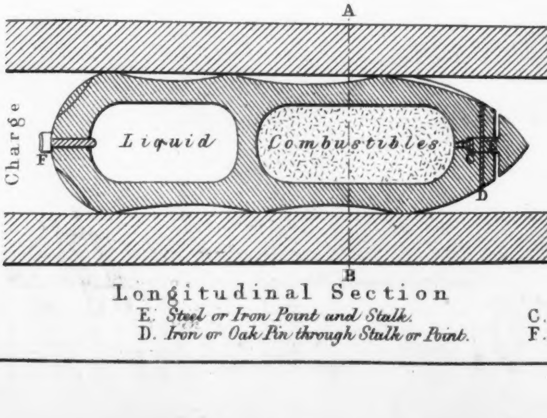
Elevation of Shell.

Fig. 4.



Elevation. 3½ Diameters.

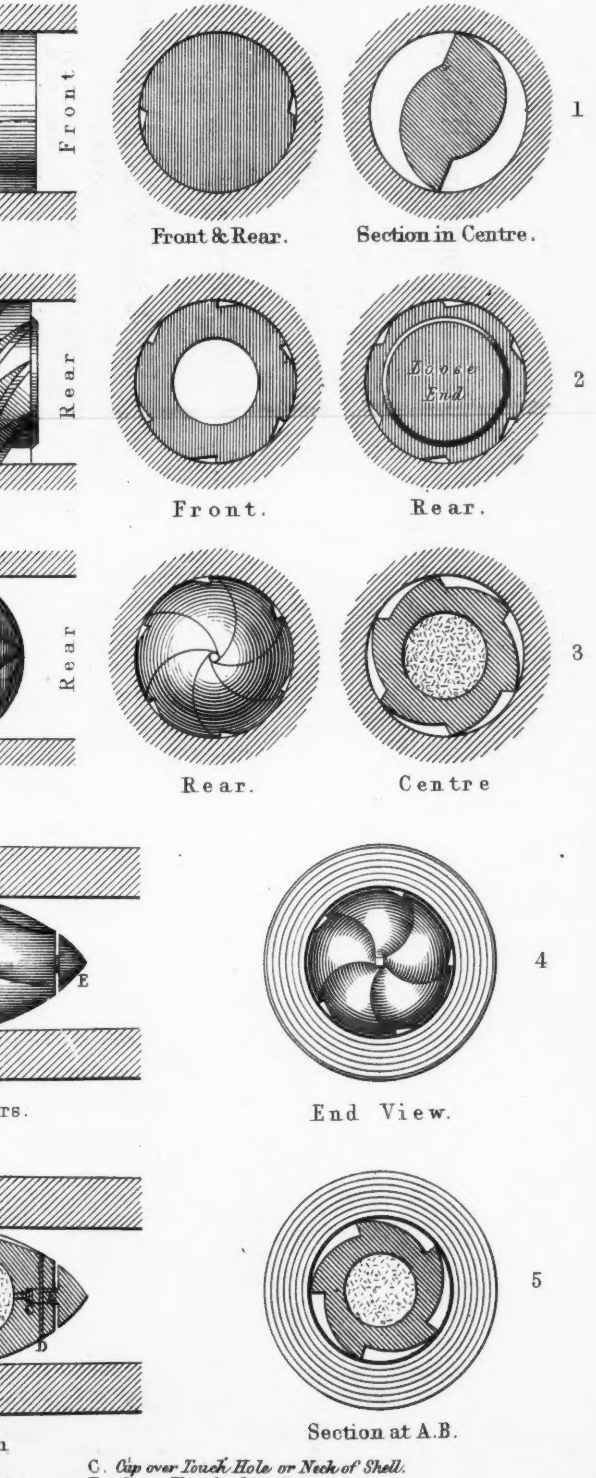
Fig. 5.



Longitudinal Section

E. *Steel or Iron Point and Stalk.*
D. *Iron or Oak Pin through Stalk or Point.*
C.
F.

D PROJECTILES,
TH BORE GUNS



oint.
C. *Cap over Touch Hole or Neck of Shell.*
F. *Screw Plug for Liquid.*

J.R.Jobbins.

Evening Meeting.

Monday, February 6th, 1865.

Captain E. GARDINER FISHBOURNE, R.N., C.B., in the Chair.

NAMES of MEMBERS who joined the Institution between the 16th of January and the 6th of February.

LIFE.

Prendergast, L. M., Lieut. 52nd Light Infantry. 9*l*.
Best, Hon. Henry, Mid. late R.N. 9*l*.

ANNUAL.

Hybert, Thomas, Lieut. Royal Naval Reserve. 1*l*.
Luard, C. E., Lieut. Roy. Engrs. 1*l*.
Collen, H. H., Lieut. Roy. Art.
Hurst, W. B., Lieut. Roy. Engrs. 1*l*.

ON GUNS AND CAIL'S RIFLED PROJECTILES.

By R. Cail, Esq., C.E.

Mr. Richard Cail: I have the honour of appearing before you to-night to explain a system of using rifled projectiles in place of rifled guns. I shall endeavour to point out its advantages; but before doing so I will, to a certain extent, explain the diagrams and models. Here (Fig. 1) is shown a solid rifled shot, three diameters long. The length which might hereafter be found to be best can only be determined by practice. This is the rear of the shot where the charge is applied. This other projectile (Fig. 2), which will show it better, is of considerable length, but is lightened by those deep spiral grooves being cut in it; and when the gas is rapidly generated, and the gun requires ease, it would come into these rifled sinkings, strike upon the rifling, propelling, and giving rotatory motion to the shot and ease at the same time to the gun when the gas is so rapidly generated. It could only be determined by practice how much space for the exit of gas should be left open in front—it might be very small, or it might be none at all. The principles of this rifling are that you get a shot in the best form

for going through the air and with the least resistance; the deep sinkings easing the gun at the same time doing useful work. Here is another form, a cylinder (Fig. 2), hollow in the centre, with a loose piece put on, which would fall short of the shot, and the air would pass through it. The reason I adopted this form was to get a greater length and more surface for sinkings. Here are other forms (Figs. 3, 4, 5). These have caps, with an iron pin put through, and when they strike, the blow breaks the pin, fires the cap, and so explodes the shell. This is a casting from the same model. There is no difficulty whatever in casting them. This is cast to be used as a shell. As those sinkings have no accurate fittings, and nothing but the gas to act upon them, it is of no consequence about their being exact in any way. The surface itself can be put into a lathe and turned very easily. The surface to be turned being very small, there are only these points that would be taken away. With these remarks I will now read the paper:—

The following considerations are with reference to guns and projectiles generally; also, reasons in favour of adopting a new system of rifled projectiles.

The heads into which I divide the subject will allow of their being taken separately for comparison with other guns and projectiles; but practice alone can determine details, and as what I shall hereafter advance is also matter of opinion, the same rule will apply throughout the remarks in this paper.

My system is to fire rifled projectiles from smooth-bore guns, the rotatory motion being given to them, in the gun, by the gas, which will be more fully described hereafter.

In treating this subject in a novel and different manner from all the scientific and practical men of this and other nations, I lay myself open to criticism; but the principles of my system appear to me correct and simple, which induces me to bring the subject forward for examination.

If my system proves correct, it may seem strange that the Government, and many to whom I have explained it, should not have taken it up; but I attribute this to its not being understood, and having come to a conclusion that it was something different from what it really is, they have not patiently examined it. To this rule there have been exceptions, but they have not had the required influence to get my principle a trial. Another reason is, that, from its simplicity, it has not been deemed worth consideration. I am well aware that there are many men pursuing this subject, of far higher attainments than I can pretend to, but their minds have, and are being directed to more complicated, ingenious, and seemingly more clever systems, which has caused them to overlook what I conceive to be the true principles of gunnery.

Similar cases have occurred before with other things; for instance, the application of locomotive power to railways was delayed for a long period by scientific and laborious men, who gave their time to the subject, persistently making efforts to overcome a difficulty which did not exist.

After years of study, and trying many clever inventions, to enable a

locomotive to get sufficient friction, or hold of the ground or railway, by legs pushing behind worked by the engine, by racks and wheels, &c., &c.; at last, upon trial, it was found that the friction between the rail and the wheels of the locomotive was sufficient, when the supposed difficulty and inventions vanished.

Seeing locomotives drawing their ponderous loads behind them on the smooth rail, it seems almost incredible that so many able men could overlook the truth so long, and not have tried what is now so obvious.

The fact is, it was too simple to be thought of or suggested; their minds were on the wrong track, each new plan causing fresh efforts to be made in the same direction, and the simple truth and true principle were buried in complicated inventions.

I conclude rifling guns is a parallel case, on which so much ability has been devoted, and so many millions of public money expended.

The system I advocate is so simple that, with all due deference and respect to the men of the rifle school, and to those in authority, I think it should have been thoroughly tested, even with a remote chance of success; this I wished the Government to do, and offered to supply shot. I also begged the loan of a gun, in order to make the experiments myself, but without success.

In the following remarks, I am aware many are superfluous, but I am anxious for a full consideration of the subject.

The heads are as follows:—

1st. Simplicity of gun; its durability; small cost of gun and projectiles.

2nd. Initial velocity of projectiles; general form of projectiles.

3rd. Continuation of velocity after leaving the gun; length of range; accuracy of aim; rotatory motion and how obtained; weight of metal projected; why suitable for shells; easing the gun, freedom from recoil, and reaction; general remarks.

1.—*Simplicity, Durability, and small cost of Guns and Projectiles.*

It must be admitted the above are most important points, and a plan which proposes to combine them deserves consideration. The system I bring before you does this; the guns to be used for my rifled projectiles being of this class, namely, smooth-bores and muzzle-loaders, the projectiles, also, being easily and cheaply made.

The present stock of cast-iron guns, as they are—the same guns hooped or lined with steel tubes and hooped—would do; but for large bores, heavy firing, and long ranges, I would prefer long solid steel guns, or any of good construction. It will be observed, that so far as the gun is concerned, my system requires what is of the least cost, also being of the most simple and durable construction of gun.

The immense saving which could be effected in this country by using the smooth-bore guns now on hand is of great importance in connection with my system.

I shall now contrast the above with the disadvantages of rifling, by which smooth bores and round shot have been superseded.

If two guns are made of any given material and mode of manufacture, and finished up to the stage of smooth-bores, one is ready for my projectiles; the other for all systems (except for round shot) requires to be rifled in some way or other, at great cost, and more or less injurious to the gun, as it is impossible to make the slightest groove or break the surface without impairing its strength. As a gun is an engine in which to create the greatest possible amount of force or power, without causing its speedy destruction, its strength should not be unnecessarily impaired, and, as rifling does this, if, by a change of system, in which this is not done, not only equal, but greater results can be obtained, how many would be the advantages?

As an instance of the effects produced by a slight break in the surface of iron, I mention the following fact:—

A locomotive axle, of about six inches' diameter, having the maker's name and address very slightly stamped upon it, in letters of about three-quarters of an inch high, running along the axle in two lines, the upright letters crossing the axle and fibre, was subjected to hydraulic pressure until it broke, to test the material. Where the fracture occurred there were upright letters on both lines, and at those points the fibre was cut in about three-quarters of an inch deep, as clean and smooth as if the axle had been of wood, and a mortise chisel had been driven into it for that depth. The letters were not indented more than about one-fortieth of an inch, or say about one two-hundredth of the diameter, yet this small break in the skin had formed a point of fracture.

Rifling has a similar effect on a gun, each groove forming a point of fracture.

The principle has been adopted as being considered essential for obtaining rotatory motion, and could only be justified on this account.

I purpose to avoid this by making part of the gas or power generated, perform this in place of rifling, friction, and mechanical means, which to me appear like the old plans of racks and wheels to gain friction for the locomotive to which I previously alluded.

In that case the old engineers created friction for its supposed usefulness, and the modern gun engineers do the same thing by rifling guns.

I claim, firstly, as a commencement for my system, to use the most durable, simple, and cheap gun and projectile.

2.—*Initial Velocity of Projectiles; General Form of Projectiles.*

A flat plate, projected with the greatest velocity, having the flat side to the air (if it could be kept in that position) would not go far, and if it struck an object, the effect would not be great.

If fired edgeways (which has been proposed) there could be no accuracy of aim.

Round shot and shell, which have reigned so long, and occupied such an important position for centuries, have certain advantages over the systems of rifling and low velocities, which have made their advocates cling to them through all the recent changes.

Round shot can be projected with greater force and velocity than the rifled shot in use, but not having rotatory motion, and the form also having, to a certain extent, the disadvantages of the flat plate, the accuracy of aim and destructive power is not so great as can be obtained from an elongated projectile.

I conclude that the best form of projectile is the elongated or bolt form, as combining the following points:—

Offering the least resistance to the air, and, from its form, being more destructive than round shot.

Accuracy of aim, from being able to obtain rotatory motion.

Length of range, from the form, and having rotatory motion.

Secondly, I claim for my system to be able to obtain all the advantages of the greatest initial velocity of any rifled projectile, combining the best form of projectile.

3.—*Continuation of Velocity after leaving the Gun; Length of Range; Accuracy of Aim; Rotatory Motion and How Obtained; Weight of Metal Projected; Why Suitable for Shells; Easing the Gun, Freedom from Recoil and Reaction; General Remarks.*

I take it for granted that no form of gun, or any mode of construction, creates power, but that the force or motive power at command in using any gun is in proportion to the quantity of powder which can be exploded with safety.

That the quantity of powder exploded, or power, which may with safety be generated in the same gun, much depends upon the application of the power when generated.

If, for instance, with a given quantity of powder, the flat plate previously mentioned, were placed in front of the powder, on explosion, it would be easily forced forward, and, as the power was generated, the gun would get ease.

The quantity of powder might be increased to a great extent with such a projectile without straining it.

And again, if a round ball were placed in front of the same charge of powder, the resistance and strain upon the gun would be greater, but the round ball having nothing to detain it, and not being difficult to move, as the power was generated, the gun would get ease. This form of projectile does not throw great strain on the gun, so that large charges of powder may be used with comparatively little damage to it, and the shot sent out with great initial velocity. It is also cheap, simple, and easily managed and kept in order, but long ranges and accuracy of aim cannot be secured without elongated shot and rotatory motion.

With regard to the systems of rifling which have to so great an extent superseded round shot and smooth bores, I maintain that they are all wrong in principle.

In using any form of rifled gun with shot to suit, with coatings of lead, studs, &c., to create friction between the projectile and gun, when the powder is ignited, and the power or gas is being rapidly generated, and the elongated shot at rest, the weight, being greater

than that of round shot, throws additional strain on the gun. But the serious part of the business is, that it is not free to move, but is retarded from moving forward by the means employed to get rotatory motion, and in place of the projectile being driven forward nearly as fast as the power is generated, the strain upon the gun is enormously increased, both at the first shock and all the way as it is being forced to the muzzle,

Retarding shot in a gun by lead coating, or other means, appears to me to be performing an operation the reverse of what is required, and is more like the application of powder when used in blasting rock.

In this operation, a smooth hole is drilled in the rock, and the powder placed in the bottom (corresponding with the chamber of the gun), the hole being stemmed in with clay, sand, &c., and in proportion to the resistance of the stemming, you obtain the desired results from the powder. If it affords the required obstruction to the gas, the rock is torn or blasted; if it is loose and is too easily projected, then the blast is lost for the purpose intended.

In proportion as the shot is retarded in a gun, either by its own weight, or by lead coating, &c., it resembles good stemming in the drill-hole, and an operation is performed in the chamber of the gun which is aimed at in blasting rock, that of blasting or destroying the gun.

The power which has been employed in forcing out the coated shot should have been employed in projecting it with greater velocity.

After all this sacrifice of power of propulsion, which is shown by the low initial velocity obtained being far behind that of the old round shot and smooth bores, the rotatory motion (which is so desirable) is dearly bought. As the diameter of guns increases, the disadvantages of rifling and retarding the shot rapidly increase. The strength of the materials of construction being the same, the requisite strength cannot be obtained to stand the strain of the increased friction from the projectiles of large diameter acting like a brake on a wheel, and makes it impossible to use heavy charges of powder to obtain high initial velocities, which is most important.

If large guns are used on this principle, short projectiles, small charges of powder, low initial velocities, and short ranges must be the result.

For small guns, such as field-pieces, firing bolts with charges of from two to four pounds of powder, there is no difficulty in making them strong enough to stand and last a considerable time, as the power generated is less in proportion to the strength of the gun, but the same needless waste of power occurs, although the faults of the system will not be so apparent.

It was by firing small bolts with rotatory motion from a gun of this description which took many by surprise, that a conclusion was hastily come to, that this was the correct system.

A projectile should be propelled with all the force or initial velocity that is possible; to accomplish this, all the power generated should be employed in effecting it, and there should be no avoidable friction between the gun and projectile; this result with a projectile retarded by

lead coating, grooves, studs, buttons, &c., or any mechanical means creating friction, is not compatible.

In my system all the parts of the projectile coming in contact with the gun are smooth, and fit the bore, which is also perfectly smooth, so that between the two, there is the least possible amount of friction.

The only work the gas, or power generated, has to do is to overcome the small amount of friction between the smooth surfaces of the gun and shot, the dead weight of the projectile and the resistance of the air, common to all projectiles; thus it is obvious that the greatest amount of initial velocity will be obtained by the power generated.

Other systems require the guns to be rifled in various ways in order, by the connection of the shot and gun, to obtain rotatory motion. By mine all is done by part of the gas or power generated without friction or mechanical means, and the gas employed in giving rotatory motion is useful in propelling the projectile whilst it spins it, so that little power is lost. From there being so little friction and strain on the gun, I conclude that by my system only will large elongated projectiles be used successfully in conjunction with length of range.

The mode I obtain rotatory motion is as follows:—

The elongated projectile fits the smooth bore of the gun in all its length, and has deep spiral lines of rifling carried along its sides, which terminate with an opening to each at the front, to allow the escape of the gas, of such a size as will be determined by practice, and at the rear, the rifling or sinkings terminate by a band, or part fitting the bore, where the escape of the gas from the rear to the body or sides of the projectile is regulated by sinkings, leading into each line of rifling.

The gas having a tendency to go in a straight line from the rear to the muzzle, and impinging upon the quick pitch or twist of the rifling, forces the projectile rapidly to revolve in its passage through the gun.

When the projectile is long and heavy, by making the pitch of the rifling quick and deep, more gas may be allowed to pass the band at the rear, which will give ease to the gun at the time most required, that is, when the gas is being rapidly evolved and the projectile is at rest; the whole spaces along its sides are available for filling, before the intense strain is thrown upon the gun, which takes place when lead-coated or retarded projectiles are employed. As previously stated there is no impediment to the shot moving easily forward, except the slight friction between two smooth surfaces, the weight of the projectile and resistance of the air; and as a natural consequence the shot will move forward by the action of the gas on the rear in the usual way, being assisted by the gas which has passed the band in projecting and spinning the shot.

The rear of the projectiles, as will be seen by the drawings, castings, and models on the table, in some cases have spiral sinkings commencing at the centre and terminating at the passages for the gas to the sides, which to a certain extent will assist in imparting rotatory motion. The projectile is in a manner floated in gas, and having no mechanical connection with the gun, no avoidable strain is thrown upon it.

There is nothing to catch, get out of place or order, but all is as simple as the old smooth bore and round ball, with powers enormously increased.

The most suitable lengths for various kinds of projectiles, amount of pitch or twist, amount of gas in each case to allow to pass the rear, and amount of freedom of exit in front, will vary with the length and weight of shot, distance of gas to travel, &c., which will require some practice to determine. The grooves or rifling not having to fit any thing, but only acted upon by the gas, no nicety or exact fitting is required, and only being made of one metal there would be no chemical action to destroy them, neither would any amount of rough usage put them out of order. As no accuracy is required in the groove or rifling, they could be cast in the projectiles, or, when of wrought iron or steel, rolled and cut into lengths, or forced into moulds or swages by hammers or otherwise, or the main form given by the above or ordinary means to any blocks of heated iron or steel.

The part fitting the bore of the gun forms a very small superficial part of the surface of the projectile, this it would be best to turn in a lathe to fit the bore, the cost being trifling. After which the fitting parts might be made smooth to save friction, and the vents at each end for the admission and exit of gas taken out in the least costly manner.

The solid shot will, if of cast iron, only slightly exceed the cost of round balls, and little more than the extra cost of material will have to be added for wrought iron or steel projectiles.

The system lately adopted by Mr. Mackay, is the same in principle that I advocate, having no mechanical connection between the gun and projectile, and rotatory motion being obtained by gas; but, with all respect to Mr. Mackay, I think he is wrong inasmuch as he diverges from my plan, yet, I may also add my conviction that his results will be greater than any that can be obtained from the retarding shot principle. Mr. Mackay's plan, as published in the spring of 1864, is to use a rifled gun with a quick pitch, the projectile being a perfectly smooth cylinder fitting the bore of the gun. The gas, as well as acting on the rear of the shot, passes along the rifling in the gun, and, coming in contact with the projectile, strikes it in the direction of the spiral rifling of the gun, and communicates a degree of rotatory motion to it, without friction or retarding the shot.

Mr. Mackay uses a rifled gun with all its faults of weakness and great cost. The smooth sides of the shot being offered for the gas to act upon is also objectionable. This appears to me like turning a stream of water upon a wheel without boards or buckets for the water to get hold of, or to which to give its weight, the small amount of friction of the water on the smooth surface of the wheel being the power gained.

This method does not economise the power at command, there being great waste in the gas passing into the rifling of the gun, which it will destroy and also foul, neither will the great rotatory motion be obtained suitable for heavy charges and long ranges.

As compared with my system, the main differences are:—

Mr. Mackay uses a rifled gun, which is a dearer, weaker, and injured gun.

I use a smooth bore gun, which is cheaper, more simple and durable.

Mr. Mackay uses no mechanical means to obtain rotatory motion, and has little friction, which is good, but there is a waste of power in obtaining it.

My projectiles have as little friction, and nearly all the gas or power generated is made available, either at the rear, or what passes the rear, eases the gun, and acts upon the rifled projectile (like water on a wheel with buckets), and is used both for propulsion and rotation.

To recapitulate, I claim for my system the greater power of giving rotatory motion without friction, ensuring accuracy of aim and length of range.

To be able to project longer and heavier projectiles. Having no friction or anything to catch, combined with the above reasons, makes it most suitable for shells. The sides and rear of the shells being indented and of unequal thickness, they will fly into small fragments on bursting. The shells are simple, and can be used either as time shells or to burst on striking.

For large diameters, harbour defences, or when it is desirable to project a great weight of metal to destroy any vessel with great power of flotation, I would recommend other forms; one being a hollow cylinder, with the outside parallel, and fitting the bore, rifled in the same manner as before described, having a very quick pitch, the rifling or grooves being deeper towards the rear, to give greater weight and strength to the part of the cylinder delivering the blow. The extra depth and capacity of the rifling towards the rear affords greater means of easing the gun on the first explosion. At the rear a loose end will be fixed, which will become detached when it leaves the gun, and will fall short of the cylinder if the object fired at is at a great distance. The air will then pass through the cylinder, and when used of large diameters, a spiral plate of iron, or two pieces of plate set at an angle in the cylinder, for the air to strike on, would form an auxiliary means of rotation.

By this plan, the projectile could be made of great length and weight, from having so large a surface for forming grooves for the action of the gas to expand into; the projectile being thus floated in gas, very large charges of powder could be used.

Another form for solid projectiles, by which great weight of metal can be thrown with little resistance to the air, and by which heavy charges of powder may be used, is to extend its length, and to give the rifling a very quick pitch, to have, say two very deep grooves, having about three turns to its length, more or less, as may be found best. The rifling or grooves to be deepest towards the rear, and rather less towards the front, this will give greater weight and strength there. The front to be flat in the face, and the rear to be hollowed out or cupped.

The gas being allowed to pass along the rifling freely (the spaces being very large) will ease the gun on the first explosion, and will give time for the heavy projectile to move, also assisting in propelling, as well as giving rotatory motion. The openings in the front to be so regulated as to retain the necessary quantity of the propelling force.

The projectiles, on my system, having obtained the rotatory motion

in the gun, during their flight through the air, the smooth side of the rifling comes in contact with the air. When they strike the ground, they will not have a tendency to screw in; but, on the contrary, they will ricochet as long as they have any power or force, and on striking water they will skim along, in the same manner as a flat stone when skilfully thrown on the surface.

In conclusion, I beg to claim your forbearance for the length of this paper, and for the repetitions in discussing the subject, which I have made from my not being in the habit of writing such compositions, and from my anxiety to be understood.

The CHAIRMAN: Have you made any experiments?

Mr. CAIL: None but with air. I have been very much occupied myself, and have not had the opportunity of making any experiment, but I intend to do so when I get more leisure.

The CHAIRMAN: We are much obliged to you, Mr. Cail, for taking the trouble to come so long a distance to give us this paper. At least it is a new idea, and there is no doubt that you have hit the weak points in the old rifle system. The difficulty of getting sufficient strength, and the difficulties of obtaining sufficient velocity, arising from retardation from the various modes of getting rotation, and the additional weight due to the elongated shot, these difficulties, I have no doubt, will always cause the preference to be given to the round ball for high velocities, until materials more enduring than those we now have are obtained, or a missile on a principle that will entail less strain. It does appear to me that Mr. Cail has presented us with a principle, of which no one can speak very decidedly without experiments; but so far as appearances go, it presents a way out of the difficulty, and gives us the hope of getting effective high velocities with elongated shot. The American experiments have gone entirely in the direction of round shot. Every description of rifling that they have tried has not been found so effective as round shot against iron plates. I believe that that must be the result. It is inevitable to my mind. I think this plan does afford a way of escape, and that it is eminently worthy of an experiment. You will allow me, I am sure, to return your thanks to Mr. Cail for the time, trouble, and expense he has incurred in coming to read this paper.

Mr. CAIL: I quite agree with you that you can never get the same velocity with long shot as you can with round shot. There can never be any form of shot which will have so little friction as a round ball, that I am perfectly satisfied about.

A FEW ROUGH IDEAS FOR THE CONSTRUCTION AND ARMING OF IRON-CLAD SHIPS OF WAR.

By ANDREW A. W. DREW, M.A.

IN approaching the subject of armour-clad ships of war, in such a place as this, I feel that some apology is due from me, as I belong to a profession whose object is peace, and not war. At the same time, being the son of a British Admiral, and having associated from my childhood with sailors, I have naturally been led to take an interest in nautical affairs, and, among others, in the question of iron-clad ships. Very

early in their existence, viz., at the beginning of the year 1862, it struck me that improvements might easily be made for the greater protection of the crews while fighting the guns. I then drew up these plans, which were seen in the course of the year 1862 by at least one member of this Institution, and have since been seen by several very eminent men. I mention this, lest it should be thought as I go on that my ideas have been taken from any recent inventions, for I have myself lately heard of several plans which resemble mine in some particulars. The idea of plating the battery is my own entirely. That of fighting the guns was suggested to me by reading a report of the American "Monitor;" and as I find from a letter entitled "Who Planned the 'Monitor,'" published in *Blackwood's Magazine* for June, 1862, that she was but a copy of the invention of a celebrated naval officer– Captain Cowper Phipps Coles, of our navy— I feel that it is only right to acknowledge that this part of my plan is therefore really derived from his invention, though I was not aware of it at the time.

In laying my plans before you, and inviting discussion upon them, I wish it to be understood that I disclaim anything beyond the knowledge of a mere tyro in the art, and I simply intend to throw them out as rough ideas which have occurred to me, and leave them for abler men to deal with. In their hands they may possibly help to solve the great naval problem of the day, which may be thus stated. Given, a monster gun; it is required to construct a vessel which shall be able to fight a number of such guns while possessing the power of resisting the fire of similar ordnance, and being a *bonâ-fide* sea-going ship. I cannot, of course, say that I have solved this problem, though I do think I see the way to it.

The points upon which I mean to touch this evening are classified under the following eight headings, which I have written down, and intend to *read* as a paper, as I understand that I must be prepared for broadsides at all points:—

1. Impenetrability.
2. Power of working heavy guns.
3. Cheapness of construction.
4. Rapidity of construction.
5. Facility of repairing.
6. Light draught.
7. High speed.
8. General adaptability.

1. *Impenetrability.*—I suppose I am not far wrong when I say that this is the *chief* requisite for an iron-clad ship of war; yet it cannot be asserted that we have a single vessel in our navy which is shot-proof against the 300-pounder Armstrong gun or heavier ordnance!

At present, I say nothing about the "Royal Sovereign," the solitary turret-ship we possess, because I think she is so great an improvement upon any other ship yet built, that it would be wrong to class her with the others. I omit, also, the "Scorpion" and "Wyvern," lately bought into the service, because they seem to be nothing more

than ordinary iron-clads, with turrets upon their upper decks. It must therefore be remembered, that in the remarks which follow, that class only of which the "Warrior" is still the best model, is intended to be dealt with.

All who have paid attention to such matters will remember how badly the improved "Warrior target" fared when subjected to the fire of the 600-pounder Armstrong shunt gun, at a range of 1,000 yards. Though the target was allowed to have been the strongest ever put together, it was penetrated like so much brown paper, thereby conveying the idea that the result would have been the same had the target been twice as strong as it was! And I believe that no target has yet resisted the fire of the 300-pounder Armstrong gun at the same range.

This conclusively proves that the "Minotaur," "Warrior," "Royal Oak," "Resistance," "Favourite," and all other ships of their classes, are no better than wooden vessels when opposed to heavy ordnance within the range of 1,000 yards. In short, they are *vulnerable,* though heavily armed!

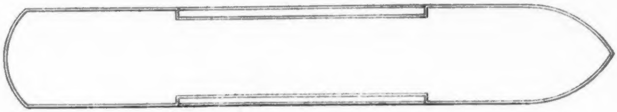
In order to obviate this grave defect in broadside ships of the above classes, I take exception to the *mode of affixing* their armour plates, feeling sure that from two principal causes they do not have fair play—first, because each plate is considerably weakened, and rendered liable to crack, by being drilled all over with bolt-holes; and, next, because the plates themselves are affixed upon a false principle, viz., *perfect rigidity.*

It appears to be assumed that to make a ship invulnerable, her armour plates must be backed up with huge baulks of timber, and the whole bolted together so as to resemble a rigid mass of conglomerated wood and iron. The results are that if plates of $4\frac{1}{2}$ inches thick are to be used, and a high degree of speed attained, the size of the ship must be equal to that of the "Warrior," and that the vessel when so built will be a total failure in the most important particular, viz., impenetrability. It is, I maintain, chiefly the *false principle* upon which our ships are armour clad, to which we owe their failure in this respect.

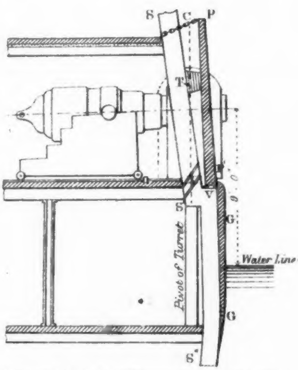
Why it is that the principle of *rigidity* should be applied to the study of one set of dynamical forces (as in the case of iron plates bolted to the sides of a ship to resist the impact of shot), and the principle of *elasticity* be applied to another set of similar forces (as in the case of the spiral spring of the buffer upon a railway carriage to lessen the force of a collision), is indeed passing strange!

Long experience has proved that the elastic spring of the railway buffer is the best medium of resistance in the case of a collision of solid bodies upon a railroad; but a rigid backing of timber is held to be the best medium of resistance in the case of the iron-clad ship and the impinging projectile.

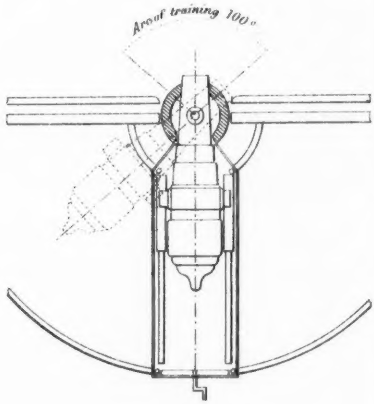
But perhaps the *principle* will not be defended, and it will be urged we only employ it because it is the most practicable. In this case it will be said, "Granting that the principle of elasticity applied to armour plating is right in theory, how can it possibly be carried out in practice?"



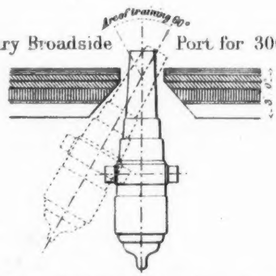
Deck Plan. (*not drawn to Scale*)



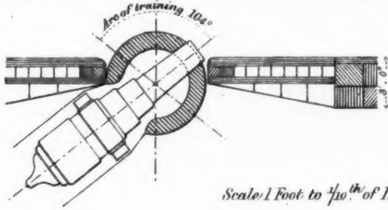
Part of Midship Transverse Section
of proposed Iron Clad Ship



Ordinary Broadside Port for 300 Pr



Proposed Port for 300 Pr fitted to Ordinary Iron Clad Ships.



Scale 1 Foot to 1/10th of Inch.

J.R. Jobbins.

I answer, that although I am not able to apply the principle to the whole of the ship, yet I can do it to the most important part, by the following means:—

Let an ordinary, but strong iron ship, be built according to the plan shown in Plate xviii, but upon the best lines we have, say those of the "Warrior." This ship let us, for the sake of distinction, call the "Champion." She will differ in no material respect from any first-class iron screw steamer, such as the "Himalaya," except in having the knee S′V in the construction of her framework, and perhaps in being a trifle heavier in her scantling. S.S.′S.″ (Plate xviii) shows the skin of such a ship as she might be sent to sea as a passenger ship or transport.

G is a strong iron girder running round the ship from stem to stern, the upper edge of which is of considerable thickness, and is carried a few inches above the knee, to protect the lower edge or joint of the armour plate when in position, and the lower edge of which tapers away to almost nothing at a distance of 5 feet below the water line! This girder forms a belt 10 feet broad, protecting the water-line, screw, and rudder-head; its average thickness is 6 inches. No timber backing would be employed, as it is held the great thickness of the belt would of itself be a greater protection than the usual 4½ inches of iron with teak backing. Now the ship is ready to have her battery, engines, and magazines protected from vertical fire. For this purpose let 4½ plates be introduced, just as they came from the maker's hands. No bolt holes, or any permanent fastenings will be required, and the only peculiarity will be that each plate must be thicker at the *lower* than the *upper* end, and have had its lower edge grooved in the manufacture. Thus the whole strength of the plate will be preserved, and the first cause of weakness which has been mentioned entirely done away.

Instead of placing these plates horizontally, as at present, let them be placed perpendicularly. P.P.′ (Plate xviii) represents a single battery plate in position. V is a roller upon which the grooved edge of the plate rests. The groove and roller (the latter a fixture) will then form a universal joint, upon which the plate will work in a direction at right angles to the ship's side. T is a strong steel spiral spring, firmly attached to the framework of the ship, but moving freely upon the inner surface of the armour plate.

The pressure of this spring keeps the plate out in position, and acts as an elastic backing, allowing the plate to recoil when struck by shot, and afterwards forcing it to resume its former position.

C is a strong chain, or *other sufficient fastening*, and is used for keeping the plate from falling outwards, and for another purpose hereafter to be mentioned. This chain is secured inboard with a running tackle, by means of which the plate is made to bear firmly on the spring, to keep in a line with its fellows, and to tumble home slightly, thereby, as it were, throwing the plate off its balance.

The "Champion's" battery will now resemble a number of separate targets, each backed by a strong elastic medium, but, except when struck by heavy shot, will be as rigid as the sides of an ordinary ship.

Thus the desired principle of elasticity will be brought into play, and the best hope secured of resisting the impact of heavy ordnance, without having recourse to colossal ships with perfectly gigantic armour.

It has been suggested by a very high authority to whom these plans were submitted, that although the principle involved is a step in the right direction, yet in the plans as they stand there would be a danger of the plates being carried away bodily under very heavy firing *from lack of sufficient fastening.*

This is quite possible, though I should not anticipate it, owing to the great weight of the plates (upwards of three tons each), and to the power of the chains keeping them in position. If upon trial this defect should be found to exist, it could easily be cured without sacrificing the important point of having each plate practically removable at a moment's notice, a point to which great weight is attached, as will appear under section 5 of this paper. The cure would consist in the employment of twin eye-bolts, one pair screwed into the lower end of the plate upon the inside, and the other pair fastened to the knee. These would be connected by a through bolt, removeable at will by means of a lanyard, and would then form an exceedingly strong hinge, which, with the chain and the dead weight of the plate, must be amply sufficient to guard against the possibility of the plates being carried away bodily.

It may also at first sight be objected, that the inertia of a mass of iron at rest, such as an armour-plate is, would be so great that a shot would pass through it before there was *time* to overcome that inertia, and to act upon the elastic backing.

To this it is replied, the plates are not in a state of inertia at all, but are only kept from falling back by the pressure of the springs. They are therefore in a state of arrested motion, so that when struck by shot that *tendency* to motion which they already have is only converted into *actual* motion by the additional external force. In so many words, the shot, at the moment of impact, acts immediately upon the spring; the plates are but the protection of the springs, and the projectiles cannot *begin* to penetrate the plates until the resistance of the springs has been entirely overcome.

It is further maintained that when the proper strength of the spring has been determined (and it should be strong enough not to move at all, or only to move slightly when the armour plate is struck by a shot which would fail to penetrate if only supported by the inner skin and ribs), then not even the unconquered 600-pounder could both overcome the whole resistance of the spring, and have left a sufficient momentum either to penetrate or to shatter the armour.

The principle involved is one which, besides being known and carried out in the railway buffer to lessen the effect of bodies in collision, is also practised in catching a cricket-ball, which is to the human hand a projectile travelling with immense velocity and weight, but which is easily arrested by the hand by slightly drawing it back at the moment of impact. The cricketer knows that if he were to attempt to arrest the ball with his hands rigidly fixed in one position, he would fail to do it, and would besides have his fingers nearly broken as a reward for

attempting to arrest a projectile upon a false principle, viz., rigidity. Yet in our existing iron-clads we are asking them to assume this false principle with their rigid timber backing, and we wonder they fail to arrest the ponderous masses of iron or steel which are hurled against them in the shape of shot and shell. Give the armour plates the slight motion they require, and they will as surely defy the attack of the heaviest ordnance as a good cricketer will catch a ball thrown at him with the greatest force by the practice of the same principle, viz., *elasticity.*

No doubt I shall be told that experiments have been tried at Shoeburyness with elastic backings, such as india-rubber, cork, and other substances, and that they *have all failed signally!* This I know, and should have anticipated, as none of the substances tried could give the *required amount* of elasticity. They were practically *rigid,* and of no strength in themselves. Nothing but a suitable spiral spring could give the necessary amount of recoil, and possess the power of repeating the effort *ad infinitum.*

Next I shall be told that a cricket-ball, if it had the same velocity as a cannon-ball, would take a man's hand off, however dexterous he might be! This I allow, but if the velocity of the cricket-ball is in imagination to be increased, then I must have an imaginary man whose eyes are good enough to see the ball coming, and whose hands are quick enough to draw back upon impact, and then he will catch the ball as before, notwithstanding the increased velocity.

This, however, is not a fair way of looking at the question. All I mean to say is, that the human hand, in itself a weak and fragile thing, is able to arrest a projectile made of solid leather weighing 4½ ozs., and travelling with a velocity of at least 80 feet a second. In comparing the cricket-ball with the cannon-ball, I make a kind of proportion sum of it, and say, as the strength of the human hand with its spring is to the smashing force of the cricket-ball, so is the strength of the iron plate with its spring to the smashing force of the cannon-ball. Now, in the first case, the result on the hand is *absolutely nothing,* and I think the result on the plate in the other case would also be *nothing,* if the experiment was properly carried out.

Next I shall be told that when collisions do take place upon railroads, it is not found that the buffers save the smashing up of the carriages, and therefore springs would not be likely to save the armour plates. I shall also be told that the velocities of a train and a shot are not to be compared to one another, and *therefore* their effects cannot be compared. But let us see about this!

A railway accident took place just before Christmas within almost a stone's throw of the house in which I was living. An express train going at 40 miles an hour ran into six ballast waggons which were stationary. The ballast waggons had no buffers, the passenger train many. The former were smashed to pieces, while in the latter *only two carriages* were destroyed; and a letter, which appeared in the *Times* a day or two afterwards, shewed clearly that nothing but the buffers saved the whole of the express train from being ground to powder. The writer of that letter said that it appeared to him, in the fore part of the

train, as if they were running into a solid substance (as indeed they were, for the waggons were full of stone), but yet the buffers upon the carriages in the middle and the end of the train so far broke the force of that fearful collision that the passengers in those carriages were only aware (as the writer said) of a somewhat "rude stoppage." It was as though the line of buffers throughout the train had been one long spring, a small portion of which was overcome by the collision, but the remainder of which broke the force of the blow. And now to estimate the force of that blow! It was at least 30 times as great as the force of a 300-pound cannon-ball having a striking velocity of 1,200 feet a second.

The momentum or quantity of motion in a body is found by multiplying its velocity into its *mass;* but as I cannot here estimate the mass of the train, I shall in what follows take the relative *weights* to be the relative *masses* (and they are really in proportion). I also assume the weight of the express train to have been 100 tons, which is under the mark, and I find that its velocity was 60 feet a second, as near as possible.

Now let V = velocity of a 300-pr. on impact = 1200 ft. per sec.
V′ = velocity of express train = 60 ft. ,,
W = weight of shot in cwts. = 3 (nearly)
W′ = weight of express in cwts. = 2000

For an equality of momentum we must have—

$$V\,W = V'W'$$

$$\text{But } V\,W = 1{,}200 \times 3 = 3600$$

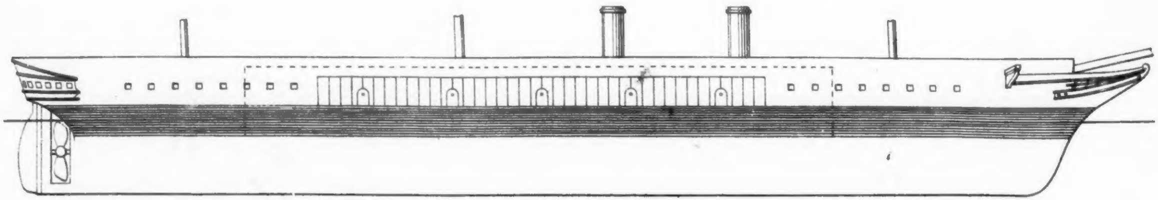
$$V'\,W' = 60 \times 2000 = 120000.$$

Or, the momentum of the train was 33 times as great as that of the 300-pound cannon-ball. Yet the effect was so small upon the express train, that only about two carriages were destroyed, and the remainder, which were composed of thin wood backed by springs, were unhurt.

As far as the effect upon the express train goes, it was the same as if the ballast waggons had struck it with the same velocity. In that case we have a projectile of enormous weight, and comparatively low velocity, producing very little effect upon a train protected only by springs. Imagine an armour plate backed by springs of the same strength, and I think no one will say that it would have taken much harm from the same blow which the train received. But I shall here be reminded that, for piercing armour plates with projectiles of a similar form, penetration varies as the *square* of the velocity into the weight. Very good. The weight of those six ballast-waggons full of stone was 60 tons. If the express train had carried a piece of armour plate affixed to the front buffers, and the ballast-waggon had a 300-pound shot of the same form as the Armstrong projectile, fixed as a kind of spur, so as to strike the piece of armour plate, then the penetrating force may be estimated and compared to that of the Armstrong projectile.

V = velocity of shot on impact = 1200 feet per sec.
V′ = velocity of ballast waggon = 60 ,, ,,
W = weight of shot in cwts. = 3

CHAMPION.

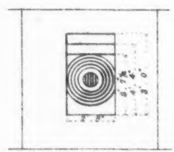


Length .... *380 Ft.*
Beam .... *58 Do.*
Nature of Guns 10. 300 Prs.
Wt. of Broadside .. 1500 lbs.
Arc of Training ... 100°

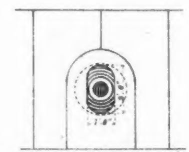
The dotted lines show the extent to which the Warrior is plated.

Scale 60 Feet to 1 Inch. Warrior Lines.

Speed *14.6*
Men *500*
Tonnage *6109*
Draught of Water ... 25 : 8
Thickness of Belt ..... 6 ins.



Scale 1 Ft. to 1/10 of Inch.



Broadside Port of Ordinary Iron Clad,
Admitting of 7° Elevation 2 ft. 9 x 3 ft. 7½ = 9.968 Sq. Ft.
Outside Area „ 12° „ 2 ft. 9 x 4 ft. 4 = 11.916 „ „
„ 18° „ 2 ft. 9 x 5 ft. 0 = 13.75 „ „

Proposed Broadside Port of 300 Prs.
Area 1 ft. 8 x 3 feet = 5 Square Feet.
Angles deducted 4.233 Square Feet.

J.R. Jobbins.

W' = weight of ballast waggons in cwts. = 1200

For equality of penetration $V^2 \times W$ should equal $V'^2 \times W'$.

$$\text{But } V^2 \times W = 1{,}200^2 \times 3 = 4320000$$
$$V'^2 \times W' = 60^2 \times 1{,}200 = 4320000$$

Or in so many words, the penetration would be the same in both cases. But, as I have said, that blow was struck upon a few timber carriages protected by buffer springs and no great effect produced, therefore, *à fortiori*, no harm would be done to the armour-plate, backed by springs of equal strength, when fired at by the 300-pound shot having a striking velocity of 1,200 feet a second.

Section 2.—*Power of working Guns.*—Under this head it is asserted that the "Champion" would present all the advantages, without the disadvantages of an ordinary broadside ship, together with the protection of the turret system, and the same capability of carrying heavy guns. While the main or fighting deck will have the roominess of quarters, the light, ventilation, and comfort of a wooden frigate; it will also form a perfect protection for the gunners. And although the "Champion" would be, properly speaking, a broadside ship, yet she would carry a few very heavy guns in preference to many light ones; for instance, instead of 40 guns as the "Warrior" has, the "Champion" would have 10 guns of four times the weight, and be the more powerful ship too, for it is well known that one really heavy gun will do more execution in ten minutes than a whole broadside of lighter guns in half-an-hour. It may perhaps be doubted whether large guns such as the 12 ton 300-pounders could be worked upon the broadside. They could with ease, and the method of accomplishing this and the other advantages before-named will be as follows:—

Let small half-turrets of a cylindrical pattern, with spherical heads, be placed upon the broadside in the position in which an ordinary port would occupy. These broadside turrets would be open to the fighting deck, but would present the appearance, externally, of perfect turrets. (See Plate xix). Like midship cupolas they revolve upon pivots in their centre, carrying their guns with them, to the extent required for training the guns fore and aft (See Plate xix). The gun-slide is attached to the base of the turret, and the whole is set in motion by a winch acting at the rear end of the gun-slide, which resembles a lever of the second order, the power acting at a considerable distance from the weight, in which case a very small power would be sufficient to set the turret in motion; so small that one man could in all probability train the gun by himself.

The weight of the gun is borne partly on the pivot of the turret, (which would be a hollow cylinder of great strength, and be perfectly protected from shot by the turret itself), and partly on the wheels of the gun-slide. These wheels would be flanged, and run in circular ways let into the deck. The diameter of the broadside turrets would be only four feet over all, and their height six feet. The two armour-plates nearest the turrets are shaped out so as to fit over them and to recoil upon their springs without exposing the men at the guns.

The turrets are pierced only sufficiently to admit the muzzle of the

gun, and to allow it to be elevated or depressed seven or eight degrees, so that no shot can possibly reach the gunners unless either the armour or the turret is first penetrated. The gun-slide, with all its apparatus, should be of iron, the wheels of the carriage deeply flanged, somewhat like those of the slide, and made to run on iron ways resembling an inclined plane with a rise of 1 foot in 18.

One of the great disadvantages of a broadside ship of the usual construction is, that the guns can only be trained, laterally, to the extent of 30° each way, making an arc of training of 60°

Another is, that the guns require to be trained by manual labour, and that a few hours' hard fighting is sufficient to tire the crew of the gun.

A third is that a large number of men are absolutely necessary to work even a 68-pounder, and therefore the large increase of men must practically limit the size of the gun which can be worked upon a broadside ship, especially as with their present large complements, few ships can fight both their broadsides at once.

A fourth is, that ships of this kind can never use the 12-ton gun as a broadside gun on account of the large port which would be required for fighting and training them.

To take these four objections in order—

1. From Plate xix it will be seen that the revolution of the turrets upon the broadside will allow the guns to be trained laterally to the extent of 50° each way, making an arc of training of 100° against 60° in an ordinary broadside ship.

2. The guns of the "Champion" are trained by the revolution of the turrets, much as Captain Coles trains his guns in the central cupola, and therefore with the machinery which has been described very few men would be required, while the labour is so small, as compared with working a gun in an old-fashioned port, that Captain Coles, in a lecture delivered at this Institution, stated that in a trial of a 40-pounder in a cupola, against a similar gun in a broadside port, the crew of the latter gun were fairly tired out, and gave in as beaten, while the crew of the former were as fresh as ever.

3. From the fact of the "Champion" fighting all her guns upon the cupola principle the usual rule of the increase of men in proportion to size of gun would not hold good; and it is found that with a 300-pounder in a heavy central cupola a crew of 14 men is sufficient to work it. The broadside turret being infinitely lighter, and the men having abundance of room, I think a 300-pounder could be worked upon this principle by 12 men. At all events the limit of the size of the gun need not be reached yet, on the ground of the great increase of the number of men required! On the contrary the "Champion" fighting 10 300-pounders, with a crew of 15 men for each, would only require a total crew of 300 men in order to work both broadsides with one watch. Probably a crew of 500 men, all told, would be enough to man her efficiently.

4. As regards the size of port it will be seen at a glance that the objection is done away with in the "Champion" by the employment of the broadside turret, which fills up the space which the large

port would occupy, and provides for the due training and working of the guns (see Plate xix). I understand that the exposed area of the smallest port which would suffice for fighting a 300-pounder is 9·968 square feet. The dimensions of the opening for my broadside turret gun are 1 foot 8 inches by 3 feet, giving an exposed area of 4·233 square feet, and commanding greater elevation, and nearly double the amount of training. But it may still be said there is no proof yet that a broadside ship could carry any number of those monster 12-ton guns! The assertion is the "Champion" could carry ten such guns.

The "Warrior" is supposed to carry 20 guns on a side, each of them a 95 cwt., 68-pounder. The aggregate weight of these is of course 95 tons. This would allow five guns on a side, each weighing 19 tons. But we only require 5 guns weighing 12 tons each; therefore with this armament the "Champion" would be carrying 35 tons a side less than the "Warrior" while throwing a heavier and far more destructive broadside than that ship. As the guns would all be pivot guns proper, there can be no good reason why their great weight, individually, should prevent their being carried upon the broadside, especially as their aggregate weight would be less than the aggregate weight of the guns now carried by the "Warrior" upon her broadside. The height of the "Warrior's" guns from the water is 9 feet. The "Champion," drawing some inches less water, would carry her guns the same number of inches higher out of the water. The weight of the "Warrior's" broadside from protected guns is 884 lbs. against the "Champion's" 1,500 lbs., and the latter could with ease deliver two such broadsides at once, using less than one-third of her crew.

Section 3.—Cheapness of Construction.—Although as a nation we do not grudge the highest price for a good article, yet there is every reason for securing a better one at a lower price if we can do so.

The "Warrior" cost in round numbers some £350,000, and she is undoubtedly a good ship. The "Champion" would be a better, as I think will have been proved by the time we reach the end of this paper, and she would be less costly.

Supposing the framework of the two ships to be exactly the same both in construction and in price, there being no timber-backing at all in the "Champion," the cost of the "Warrior's," 333 tons of teak, and of working it up and fitting it to receive the armour, would be so much clear gain. Then again, the "Champion" has only her belt drilled for bolt-holes, and short bolts would be used; whereas the "Warrior" has the whole of her armour drilled, and long bolts are used. In these items there would be a very large saving in material and workmanship, and therefore in cost. But in reality the framework of the ship need not be so strong as that of the "Warrior," as the weight to be carried is less, and is more centralized.

Therefore a vessel of the "Himalaya" construction and the "Warrior" lines would most probably suffice to represent the "Champion." At a very moderate computation, she would cost £100,000 less than the "Warrior," and would commend herself as being a very cheap ship. Also, that ship is the cheapest which pays

best in the long run. Now the "Warrior," built partly of iron and partly of wood, cannot from the nature of the case last so long as the "Champion," built wholly of iron; and, for the same reason, the casual expenses of repairing the former must be greater than those of the latter.

Section 4.—*Rapidity of Construction.*—It is of the utmost importance that in time of war we should be able to turn out a large number of efficient iron-clad ships in a very short time. "Warriors" could not possibly be built under 12 months, if that, either in Her Majesty's dockyards or in private yards. "Champions" in any number could be built in a few months in both.

The time occupied in building the hull would be that ordinarily required for building a merchant steamer, viz., a few months, while a large proportion of the armour plating, having no permanent fastenings, could be got in readiness for shipping during the same time, so that as soon as the ship was launched she could have the remainder of her armour affixed in a few days, or as fast as it could be hoisted in. If some good plan could be found for affixing the plates forming the belt without the use of bolts (perhaps the system invented by Captain Symonds for his coast defence ship), then the time required for building would be still further shortened.

If needed, some of the strongest merchant steamers that could be found would easily admit of being converted into efficient ships of war in a very short time. All they would require would be to cut them down to the point where the knee would come, and rebuild them from that point. Of course these would be only make-shifts, as they would not have been originally as strongly put together as those built on purpose.

Section 5.—*Facility of Repairing.*—By this is meant the facility of repairing any damage that may be done to the battery plates even at sea, and to the general hull when in harbour. Supposing any given plate becomes damaged by shot so as to be unserviceable, the damaged plate could by means of the chain C (Plate xviii) and a tackle from the mast-head or yard-arm (or if these were shot away, from a small travelling derrick, which a sailor could rig in five minutes), be hoisted up a few inches, so as to clear the girder G, when the pressure of the spring would cause the plate to cant outwards. It might then be allowed to drop overboard and another plate be lowered in its place from a small stock kept on board, the whole operation not occupying many minutes. All the plates should be of the same size.

Next, supposing the bottom of the ship required repairs in some place where there was no dock available. The battery plates could all be hoisted out and deposited temporarily on board some hulk, or upon a jetty, while the vessel could be laid on a gridiron or be beached, and have her bottom repaired or cleaned, as the case might be. No such thing as this could ever be attempted by an iron-clad ship of the present construction, for fear of breaking her back.

Section 6.—*Light Draught.*—If we have two ships equally powerful, equally fast, and equally handy, but one of which draws a few inches less water than the other, that single point will give the superiority in

her favour. Now, supposing the "Warrior" *to be equal* in these respects to the "Champion," which she could not be, we find that the former, which is only partially protected by 4½-inch plates, and has her screw, rudder-head, and water line exposed (except amidships), carries a total weight of armour in plates and backing of 1,309 tons. This includes a battery 212 feet long, 22½ feet deep, and transverse bulkheads of the same depth.

The "Champion," besides an inner skin similar to that of the "Warrior," would have a *six*-inch belt extending 5 feet above and 5 feet below the water line, carried round the ship from stem to stern, protecting all the vital points. The weight of this belt, 760 feet long, 10 feet deep, and 6 inches thick, is 814 tons.

As the ship would have but five guns on a side, she would not need the same length of protection for her battery and engines. Allowing a space of 32 feet between each gun, the "Champion" would have a length of 160 feet amidships, protected by 4½-inch armour plates, backed with springs, and extending upwards from the top of the belt a distance of 10 feet. This would suffice to protect the engines and boilers and the whole of the battery. The weight of this further plating, 160 feet long, 10 feet deep, and averaging 4½ inches in thickness, is for both sides 239 tons. Two bulkheads enclosing the battery, each 58 feet long, 8 feet deep, and 4½ inches thick, weigh 70 tons. Ten broadside turrets, 6 feet high, 4 feet in diameter, and 6 inches thick, each weighing 8 tons, will be 80 tons. It will thus be seen that the total weight of armour which would be carried by the "Champion," with greater protection than the "Warrior" has, is 1,203 tons, or 106 tons less than that ship; and, as appeared from section 2, there is a further saving in weight of guns of 70 tons, so that in guns and armour the "Champion" would carry 176 tons less than the "Warrior" actually does. This means that she would draw nearly 6 inches less water than the "Warrior" at deep draught, and is one more advantage in her favour.

Section 7.—High Speed.—The buoyancy of the "Champion" being considerably greater than that of the "Warrior," it must naturally follow that there will be a proportionate increase of speed in favour of the former, supposing, as I have done, that the tonnage, lines, and horse-power of both are the same. The average speed of the "Warrior" upon her trial was 14·3. The "Champion," drawing 6 inches less water, might be expected to average 14·6; but if it were desirable to utilize the weight saved by giving her a heavier armament, she would still average as high a speed as the "Warrior." She could carry six more guns, making a total of 16 300-pounders, if the distance between each gun were reduced to 20 feet, and she would still have 56 tons to spare, and therefore be a trifle faster than the "Warrior."

Section 8.—General Adaptibility.—It will easily be seen that many important requirements for sea-going ships of war would be secured by these plans.

They could be applied to vessels of almost any size, a point which would vary according to the length of the protected battery required,

and the weight and number of guns to be carried. Indeed, though I have, for the sake of comparison, taken the "Champion" to be a sister ship to the "Warrior," I think she would show off to better advantage if she were 100 feet shorter and a couple of thousand tons smaller.

The "Champion" and all ships of her kind would command a flush upper deck for promenade, working ropes and sails, stowing boats, &c., together with ample and comfortable accommodation for the captain and officers in the uncased portion of the main deck. Since the fighting deck is protected by the armour plates, there could be several ports between each gun, opening on the space C. T. X. (Plate xviii). These ports might be filled in with iron gratings to keep out splinters or fragments of bursting shells, and would then supply light and ventilation to a much greater extent than is possible in our present iron-clads.

The lower deck for the men would be quite equal to the lower deck of a first-class wooden frigate. A continuous row of scuttles, shown at X in Plate xviii, would, like the ports on the main deck, secure light and ventilation to this deck.

And now I will conclude this paper by saying that if experiment should ultimately prove that the spring battery plates do not answer, the remainder, and especially the method of working the guns, with increased training and great protection for gunners, could easily be applied to ships with rigid sides of the present construction. The model on the table shews the application of this method to ships of either kind. I must not sit down without thanking Captain Coles, whom I have never seen, but who has most kindly given me much information which I had no means of obtaining, and allowed me the use of several of his drawings, which greatly facilitated my work in preparing this paper and the necessary diagrams.

Now, gentlemen, fire away. Engage the "Champion," and sink her if you can. You will then have done good service by disposing of questions which are sure to arise sooner or later. And if you cannot sink her or silence her guns, then take her in hand, improve her to suit yourselves, and let her go forth on the high seas as England's trusty "Champion."

Rear-Admiral Sir Edward Belcher, C.B.: Mr. Chairman, I am very happy to see on the wall pretty nearly the exact diagrams that were exhibited in the Institution of Civil Engineers about three years since, at the Institution of Naval Architects, held at the Society of Arts, and before the British Association. I do not quite understand what is meant by girders. In engineering a girder is hollow. A tank is a girder; a tubular bridge is a girder. I suppose these are solid irons.

Mr. Drew: I call them "belts;" they are solid.

The Chairman: Six inches thick.

Sir E. Belcher: In the plans published in the Journal of the Civil Engineers you will find that precise one marked "G," and the one above precisely similar, without any of the proposed elasticity above it. My plan is that they shall all be six inches square, and seven feet length-pieces easily removeable, so that when a ship goes to a foreign station she can leave them in a dockyard, and when she requires them she can put them on. They form, in fact, a moveable armour. But as regards the lower plate that brings us to the armour ship, nothing more nor less. The piece "G," which goes down below water, is the piece which is to protect the ship from being injured below the water-line. Now, the armour plate that we require for our ships of war is not for the protection of the guns; we care

nothing about our guns. Give us a bottom that will stand any shot that may be passed into it, and we will fight the guns above without any particular armour. But the armour requisite to take care of the men to fight the guns is the most important part which they seem at present to look after in the "Warrior" and other ships; and although the Government have been pleased to place the armour there to take care of us, we, as seamen, care nothing for it. We rather scout it, because any shot passing through armour will distribute splinters of iron and wood among the men, which is terrific; therefore, the great object should be, not simply to put that shield on the face of the gun, to protect the gun, and to prevent the shot coming in between the side of the gun and the men; but we want a substance on the side of it, if you will, to protect the gun and prevent any shot coming in to hurt the men. As regards the motion on the radius in the gun turret, it will be utterly impossible with a winch of that sort to train the gun to follow an enemy, or any object that happened to be moving past you, with sufficient rapidity. We rather prefer the double screw—the motion that the double screw gives in ships of war—to turn the ship more rapidly than the gun can be turned. I believe, if we stuck to the double screws, and gave an oblong or sort of oval form to our battery on deck, that we should be able to keep a series of guns bearing constantly on an enemy, which you can never possibly do by any broadside methods. So far I think Captain Coles' turrets are very important, but they are not sufficiently numerous, and they completely shield each other if you are on either bow. The diameter of Captain Coles' turret is 20 feet, and the distance asunder is 20 feet; consequently, we lose the line of fire between any two turrets equal to that angle. That would be precisely what you would have there, because you lose that train of the gun. I think, as far as the plan goes, it is a protection. I do not believe the buffer will stand the impact of the shot. I think the shot will be through it before the buffer will feel it in the least degree. In the experiments at Shoeburyness, where the sheets are placed at a very low angle indeed, and where the shot perforated clean through them—and, mind you, these plates at Shoeburyness were not supported by anything; they were plain plates—if anything like elasticity had been in question, the plates would have been indented, and would not have allowed the shot to go through.

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common with all iron guns; but it is the objection to that pivot as it is placed that made me think of this. Then Sir Edward Belcher said that we do not want armour to protect the gunners; that is to say, the main deck. All I can say is, if that be so, why have the Admiralty thought it requisite to protect the main deck? One is pretty safe to imitate the best talent of the day, and I have done so in this respect, carrying the armour up two inches beyond the line of the "Warrior." Then, it is said, it is a great objection to having plates on that part to protect the gunners, because splinters will fly about and injure the gunners. I am aware of that objection, but if it be an objection, why, I should like to ask, do we back our armour with baulks of wood, which will create more destructive splinters than simple iron. I think the effect would be that, if penetrated, the shot would go clean through, like a bullet through a pane of glass; it might kill two or three men in this way, but it would make no splinters. Then, it was said that shot would go through the battery plate before there was time for the springs to act. If that be the case, what becomes of the formula which I have taken the liberty of quoting, from remarks addressed by the Chairman to the members of this Institution on a former occasion: that penetration will vary according to the square of the velocity multiplied into the weight of the projectile. Why, either the formula is not correct, or my theory is good.

The CHAIRMAN: I do not agree in that doctrine. If the formula be true, it is applicable; if there is any change at all, it makes it inapplicable. Many of us have heard of the experiment of a candle fired at a door standing open. If you fire the candle with sufficient velocity, it will pass through the door before the door has time to move on its hinges.

Mr. DREW: It is due to the inertia and the weight of the door.

The CHAIRMAN: No, because if you fire with a low velocity, the door will shut. The mere question of elasticity comes in in another form. If you send a shot with a velocity that is in excess of the rate at which elasticity of the metal acts, the thing struck will be pierced before the action of elasticity has time to come into operation at all. In the case of the buffers on a railway, the train referred to was going comparatively slow, and the buffers had time to give out and exercise their force before any undue weight was brought upon them. But if you were to fire a shot at a buffer, and hit the buffer before it had time to recede one-tenth of an inch, the buffer would be pierced. So it would be in the case before us. And there is a greater effect with round shot as compared with the elongated shot. I believe if you get a higher velocity the penetration will be much greater, because the law is higher than that stated as to the square of the velocity. These experiments are made with low velocities, and after all it is only an approximation to what is the law. I think the results which have been obtained from round shot, as compared with elongated shot, establish this beyond question, that the shot is moving so fast, that the elasticity of the material has not time to act. Where you have the wood-backing, there is in reality elasticity in the wood, but it is penetrated before the elasticity is brought into action. Now there was a curious condition that I observed in the "Trusty." Wherever the armour of the "Trusty" was penetrated, the wood that was behind it was comparatively uninjured; but wherever the iron was not penetrated, the fibre of the wood was shaken so much, that you could take it in your fingers and pinch it to pieces like snuff, although it was strong solid oak previously.

Rear-Admiral Sir F. NICOLSON, Bart.: As the wood was rotten.

The CHAIRMAN: It is a curious circumstance that the wood should be rotten at those particular points where the ship had been struck with shot. There are other points about Mr. Drew's paper which there is hardly time to enlarge upon. I am inclined to agree with Sir Edward Belcher, that it is of much more importance to prevent ships being penetrated in the vital parts than it is to protect the men. I have said it over and over again, that the best protection is accurate firing; if you train men and let them deliver accurate firing, it is the best protection they can have; because who are they that they are to defend themselves against? They are to defend themselves against the persons that they are attacking, and if they effectually attack them, the enemy will not be able to attack them in return. That is the best defence. Protect the vital parts of your ship, take your chance with the men, and as Sir George Sartorius said here on a former occasion, if a shot passes through, give it a wide berth, and take off your hats to it.

Sir F. Nicolson: It is somewhat out of order, but I should like to ask one question. I see in the lower part of your armour-plating that it is tapered off, and I understood you to say that the armour plating went 5 feet below the water line.

Mr. Drew: Yes.

Sir F. Nicolson: Have you ever thought of what would happen in the event of the ship rolling?

Mr. Drew: Yes, that she would sometimes roll her plating clean out of the water.

Sir F. Nicolson: Do you not think it would be as well to carry the same thickness right through?

Mr. Drew: The calculation is made for the same thickness; therefore, I have allowed for the armour being carried a little lower down by tapering if necessary, or being a little thicker at the water line, I have calculated for a uniform thickness of 6 inches.

Sir F. Nicolson: I understood you to say that you went from 6 inches at the top to nothing at the bottom.

Mr. Drew: To next to nothing, but 6 inches is the *average* thickness.

Sir F. Nicolson: I am speaking from "G" downwards.

Mr. Drew: In that case I should throw the extra weight which was saved by the tapering into this (pointing); I should throw it into the water line at the sinking point.

Sir F. Nicolson: The sinking point when the ship is rolling would be below your water line when she is not rolling. When your vessel is at rest, your water line would be where it is marked now.

Mr. Drew: Yes.

Sir F. Nicolson: All below that is tapered off. If your vessel begins to roll in a slight degree, you may have large shot and shell striking your armour plate where it may not be above 2 or 3 inches thick, and in that case you will be infallibly sunk.

Mr. Drew: I should have shown the belt in this diagram of a uniform thickness, representing 6 inches; and then have said it may be placed as drawn, or else carried down lower if tapered away. With regard to the distance that the plating is carried below the water line, I am but following the Admiralty plan; the "Warrior" is only plated 5 feet below the water-line, the "Lord Warden," 5 feet, and the "Royal Sovereign," I think, 4 feet 6 inches, and the "Favourite," 2 feet 6 inches.

Sir F. Nicolson: The "Caledonia" class are plated 6 feet below the water-line.

Mr. Drew: I know they are deeper, but I do not know the depth of them.

The Chairman: I have much pleasure in offering you the thanks of the meeting for your interesting paper.

Evening Meeting.

Monday, March 20th, 1865.

REAR-ADMIRAL SIR F. E. NICOLSON, Bart., C.B., in the Chair.

NAMES of MEMBERS who joined the Institution between the 6th and 20th March.

LIFE.

Hume, Robert, Colonel 55th Regt. 9*l.*
Hume, J., Capt. 55th Regt. 1*l.*

ANNUAL.

Jacobs, M. H., Ens. Hon. Art. Coy. 1*l.*
Eardenshon J. G., Lieut., West Kent L. I. Mil. 1*l.*
Baigrie, R., Major, H.M. Bom. Staff Corps 1*l.*
Baker Wyndham, Col., ret. full-pay, Roy. Art.
Webber, C. E., Capt., Roy. Engrs. 1*l.*
Whinfield, C. W., Lieut., Roy. Engrs. 1*l.*
Bird, G. Golding, Ens., 106th Regt. 1*l.*
Simpson, D., Major-General, H.M. Beng. Army 1*l.*
Glyn, Sidney C., Capt., Rifle Brigade 1*l.*
Lock, F. E., Capt., 15th Regt.
Grier, J. J., Lieut., 15th Regt.
Pritchard, G. D., Major, Roy. Engrs. 1*l.*
Hemans, G. W., Lieut.-Col. Eng. and Railway Rifle Vols. 1*l.*
Cubitt, Joseph, Lieut.-Col., Eng. and Railway Rifle Vols. 1*l.*
Baker, T. K., Lieut., 14th Hussars 1*l.*
Blacker, W., Capt., 12th Roy. Lancers 1*l.*
Graham, H. L., Cornet, 12th Roy. Lancers 1*l.*

THE COMPOSITIONS FOR THE PROTECTION OF IRON SHIPS' BOTTOMS FROM FOULING AND RUST.

By Commander F. P. WARREN, R.N.

IN accepting the honour done me by this Institution in their request that I would read a paper "On the compositions for the protection of iron ship's bottoms from fouling and rust, and at the same time explain my mode of protecting armour-plates;" in bringing my views on this

subject before you to-night, I do so with a feeling that although I have devoted several years to this most important question, I cannot do it the full justice it requires. I will, however, as briefly as possible, for the subject is a large one, give my personal observations, and facts obtained from official reports, without going into any speculative theories. That fouling and rust do exist on the bottom of iron ships is unfortunately too plain, and chemical analysis of what arises when iron and salt water are in contact is beside the point. It is to prevent this contact, that iron ship's bottoms are coated, and it is of no practical use what name is given to the destructive agency, galvanic action, oxidation, or what not. The chemistry of the question has been discussed in papers read before this and other scientific institutions by a high authority, whose opinions I shall more than once refer to; but it is simply as to how far the several compositions now in general use, or under experiment, have accomplished the purpose intended, that I propose to direct your attention this evening, and I beg that you will kindly follow the facts laid before you only so far as your judgment shall guide, for having a plan of my own for the protection of iron vessels I feel I cannot be considered as coming into court with an unprejudiced evidence.

Judging from the numerous patents which have been taken out for the preservation of iron vessels, it would appear that the applicants imagined the want easily supplied; and that although general attention has been turned to this point for some years, a composition to effect the object, is so very simple an affair, so easy does it seem, that either the whole conditions of what are required cannot be understood, or the difficulty is underrated.

What is required is, firstly, a preservative against corrosion; secondly, an anti-fouling composition, the whole to be of such a consistency as to withstand the friction of a vessel passing for weeks through the water at a high rate of speed, a friction which wears metal itself bright, or the external preparation to be of such a nature that it admits of a gradual wasting of the surface, so as to prevent adhesion or attachment of barnacle or weed.

It is admitted that iron can be protected from corrosion by the application of red lead and other compositions for many months while the vessel is at rest, but the most successful anti-fouling preparations tried up to this time do not claim more than to keep the vessel clean for a voyage to India and back, and this under the favourable circumstances of making the return voyage with all dispatch, the remaining in harbour a month or six weeks to receive cargo being fatal to the sailing or steaming powers. There are many other points to be considered—the various temperatures, the varieties of animal and vegetable life in different latitudes, so that a satisfactory preventive in one latitude may not be attraction in another. Again, the periods of the year at which the trials are made—between the months of November and February, on the shores of Great Britain—the growth of weed is very slow, and the marine animalculæ stagnant. The trials of compositions under these circumstances give no satisfactory data. The quitting salt water for fresh in entering rivers, and the leaving fresh water for salt, removes

the incrustation. All these conditions, under which reports are made, must be duly considered in appreciating their value.

The different preparations may be classed under the heads of metallic paints, or metallic paints with top dressing, glass and pulverized glass, lime and preparation of lime, with oils, varnish, gutta-percha, India rubber, asphalte, or some other adhesive medium, to attach the metallic or vitreous portion.

I propose to take these preparations in the order of metallic, vitreous, and preparations of lime. *Of metallic*, Mr. Hay's stands at the head, as the Admiralty, who give every preparation that promises success a fair trial, still consider his the standard by which others under experiment shall be tested.

It consists of two varnishes—one protective, the other anti-fouling. It dries rapidly, and forms an enamel. As a protective it is most successful as to its anti-fouling powers. The following extracts from leading papers during the last year will give the best description:—

Times, August 5th, 1864.

The "Recruit," iron paddle-vessel, 590 tons, 160-horse-power, was taken into No. 2 dock, Sheerness, on Tuesday last, for the purpose of ascertaining the results of experiments with the compositions to prevent fouling, invented respectively by Mr. Crispin, Mr. Wilson, and Mr. Hay. In November, 1863, the port side of the bottom of the "Recruit" was covered with Hay's composition, the starboard aft with Crispin's composition, and the starboard forward with Wilson's composition. The vessel was then taken into Sheerness harbour, where she has since been lying at anchor. The following results were disclosed on examination:—It was found that the port side, which was covered with Hay's patent, and the starboard aft, which was coated with Crispin's composition, are both very foul, a large number of mussels, &c., closely adhering to the iron-work. The forward starboard, which was covered with Wilson's composition, is, so far as fouling is concerned, comparatively free, and in a far better state than the parts that have had the composition of the other two manufacturers applied to them, though it was evident that a slight corrosion of the bottom of the vessel had taken place. An official investigation will shortly take place, and in the interim the vessel remains as it came from the moorings for the examination of the parties interested.

Times, August 11th, 1864.

The patent compositions to prevent "fouling," with which the "Recruit," 6, iron paddle-wheel, 160 horse-power, now in No. 2 Dock, Sheerness, was recently coated, have been scraped off for the purpose of testing the relative merits, and deciding the superiority of the patents. In the *Times* of the 5th inst., it was reported in the Naval Intelligence that the port side of the vessel was coated with Mr. Hay's composition, the starboard aft with Mr. Crispin's, while the starboard forward had a coating of Mr. Wilson's, that it was found on inspection that the port and starboard aft parts of the vessel, to which Messrs. Hay's and Crispin's patents had been applied respectively, exhibited a considerably greater amount of "fouling" than the starboard forward part, which had been coated with Mr. Wilson's patent; but that Mr. Wilson's composition showed more corrosion of the bottom of the vessel, which is of iron, than the other two patents. The compositions having now been removed, it is evident that there has also been considerable corrosive action going on under both Mr Hay's and Mr. Crispin's coating, and that the barnacles have eaten through the composition, and have become so closely fixed to the bottom of the vessel, that on removing them the part to which they were attached, and which had become corroded, was also removed. The result is, that if anything there is less corrosion on the part covered by Wilson's composition than on the parts coated with Messrs. Hay's and Crispin's compositions, and most decidedly considerably less "fouling."

February 9th, 1865.

Her Majesty's iron-screw frigate "Resistance," 16, Captain W. C. Chamberlain, came out of dock on the 30th of January. Her bottom was found to be exceedingly foul, by which her speed had been deteriorated to the extent of about four knots an hour.

Standard, February 24th, 1865.

The "Recruit" was done over with two descriptions of composition—viz., Crispin's and Hay's; the former was completely covered with grass, and the latter with all kinds of fish, crabs, &c.

H.M.S. "Achilles," in dock at Devonport, is having her bottom recoated with Hay's composition, which operation is nearly complete. The dock shores were shifted on Monday in order that the spots which they covered might be properly coated. The "Black Prince," 41, Captain Lord Frederick H. Kerr, was placed in the Prince's dock, Devonport, on the 15th inst. The bottom of this ship was completely painted with Hay's composition in November, 1863, and partially so in May, 1864. About the middle of December, while at moorings in Hamoaze, her starboard side was "hogged;" that is, her bottom was cleaned by a large brush moved by rope guys. When in dock this side was found to be nearly clean, and on the port side there was comparatively very little weed, and but a few small mussels. Some corrosion has taken place on her bottom, especially from the line of flotation to 10 ft. below, which is the part most exposed when she rolls at sea. It may have commenced through the friction of a deeply-laden vessel (such as a collier) lying alongside. Some such cause as this has apparently been in operation, as the composition is rubbed off chiefly on that part between the mainmast and the foremast, which is that usually occupied by vessels lying alongside. However, since she has been in dock, owing probably to exposure to the atmosphere, the effects of corrosion have been exhibited more or less below, from the keel upwards. The pits in some places may be a quarter of an inch deep. There is considerable rust on the keel.

2nd. Peacock and Buchan's is an anti-fouling over coating of red lead as a preservative. This is also a successful preservative, but the drying of red lead is so dependent on the state of the weather that its adhesion cannot always be relied upon. The French Commission on their iron ships reported that the application of red lead, successful in the warm, dry air of Toulon, fails in the humid atmosphere of Brest and Cherbourg.

Times, January 31st, 1865.

The "Himalaya," iron-screw troop-ship, in the Warrior dock at Portsmouth, has had her bottom, and the preservative anti-fouling compositions (Peacock and Buchan's) with which it is coated, officially examined and reported upon to the Admiralty by the dockyard officials, who have recommended that a renewed coating should be given with the same description of compositions, after a clean scrub down, and without any disturbance of the old compositions, which are unusually well preserved. It is nine months nearly since the "Himalaya" received her old coatings of the Peacock and Buchan's compositions in dock at Keyham, and upwards of three months of the latter part of that time the ship has lain at moorings in Portsmouth harbour, giving the compositions a greater chance, therefore, of fouling than they could have undergone, had the ship been kept moving under steam on her ordinary troop duties. On the examination being made of the vessel's bottom in dock, however, there was only found adhering to the composition, tufts of short weed and slime, the greater part, no doubt, deposited by the waters of Portsmouth harbour while the ship has been lying still at her moorings. There were no other adhesions of any kind, nor was there found any appearance of rust.

February 24th.

The "Defence," 11, Captain Augustus Phillimore, was placed in No. 1 dock at Devonport on the 14th inst. In November, 1863, her bottom was thoroughly coated with Peacock and Buchan's composition; in June, 1864, it was retouched. She has been lying in harbour for the last four months, during which she was hogged.

When docked it was found that some short weed, about an inch long, and a few small shell fish were attached, but this was chiefly in quarters out of the run of the sea. She is now receiving another coat of the same composition. Some corrosion exists below the water-line.

March 3rd.

The "Valiant," 24 guns, has been placed in the Warrior dock at Portsmouth. The "Valiant" has been nearly eighteen months afloat since her launch, and with nothing on the iron plates of her bottom except a light coating of red lead, which may be termed her launching coat of bottom colour. Under these circumstances it is somewhat extraordinary that she is the cleanest ship below the water-line that has been docked at Portsmouth. In this respect she differs from the "Resistance," iron frigate, which was docked at Portsmouth after her arrival at that port from the Medway. Although her bottom had been payed over with anti-fouling compositions, some tons of mussels, barnacles, and weeds, &c., were scraped from off her bottom. A comparison of the results on the bottoms of the two ships would almost establish the belief that the greater number of the expensive compounds now being applied to the bottoms of Her Majesty's iron ships, under the name of "anti-fouling" mixtures, tend to encourage rather than discourage the growth of marine animalculæ and weeds, even in English waters. From the time the ship has been in the water since her launch, and the thinness of the coating of red lead with which her bottom was originally covered, there is necessarily a good deal of corrosion over the rivet heads and some portions of the plates, but there is no appearance of any under "pit" on any of the plates surface, such as is often seen where anti-fouling mixtures have been applied which have contained copper in their composition. It will be yet some three or four months before the "Valiant" will be ready for sea service.

3rd. M'Innes' metallic base, with a soapy top dressing. Reports on "Fairy" were satisfactory, but it has not been considered equal, as a whole, to Mr. Hay's.

4th. Green's is also a metallic paint with top dressing, which was applied to the "Achilles" for a few weeks, at a heavy cost, and then replaced by Hay's.

5th. Vitreous Sheathing (Brown's).

Hampshire Telegraph.

Glazed Sheathing for Iron Ships.—Some interesting experiments have been carried on at the Dockyard, Portsmouth, during the last two months, in order to test the efficiency of "Brown's patent vitreous sheathing," for the preservation of the bottoms of iron ships from oxidation, and also from fouling. It has been applied to H.M.'s ships "Resistance" and "Warrior," which are now afloat. Messrs. H. and J. Hall and Co., of London, the proprietors, have just finished the coating of the "Hector." Their Lordships having some doubt as to the adhesive qualities of the material by which the glazed plates are attached, gave orders that one of the most powerful shores should be placed against the plates and wedged up. When removed, the plates were as perfect as before the test; but not being yet satisfied, the Controller ordered the shores to be again applied, and with the same satisfactory result. Messrs. Hall have in their offices, we are informed, a plate that has been on the Peninsular and Oriental Company's steamship "Ellora" for two voyages, and, when removed, it was found to be perfectly clean. His Imperial Majesty the Emperor of the French has ordered a similar trial to be made at Cherbourg on one or more of the iron-plated vessels, having been most favourably impressed with the efficacy of this important invention. From the moderate price fixed for the sheathing, viz., 1*s.* 6*d.* per square foot, put on to the ship, it is certainly entitled to be recommended on the score of economy; and, if it answer all the expectations that are formed respecting it, we should think that it will be largely adopted for the use of iron ships, which are now constantly being docked to clear away the obstructions which so rapidly accumulate.

From my own experiments, the reason glass fouls, is the fact of its not enfoliating.

Vitreous Sheathing (Mr. Leetch's).

Times, February 16th.

Her Majesty's steam storeship "Buffalo," Master Commander Pook, was yesterday dry-docked at Deptford, by Admiralty order, for the purpose of examining Mr. Leetch's plan of preserving iron ships by means of a sheathing of plates of coarse glass. The "Buffalo" has been more than twelve months afloat, and has stood the test of some severe weather. The surface of the glass, as was anticipated, was totally free from animalculæ, seaweed, barnacles, or incrustations of any kind. On the removal of three of the plates, the side of the ship, bolts, &c., thus protected, were found exempt from corrosion, and appeared in as good a state of preservation as when the experimental sheathing was applied at Woolwich, as reported in *The Times*, in December, 1863. The plates, which were bolted on over a solution of gutta-percha, were so firmly attached, that after the removal of the bolts they required the hammer, chisel, and wedge to remove them.

The bottom of this vessel, coated with Mr. Hay's composition, was perfectly clean, and free from corrosion, the vessel having been twice in the fresh water of the Thames during the twelve months.

At Grimsby the screw colliers, from the fact of their running into fresh water at either end of their voyage, are kept clean for nine months with a coating of mineral tar.

6th. Lime and Preparations of Lime.—I have made experiments with both lime and powdered brick, and found the latter to exfoliate more easily than the former. There is a French patent, taken out in 1858, for a preparation of an ochreous earth, but with what results I am not aware. The "Oberon," while on the Brazilian station, was coated with lime and mineral tar, which fouled so badly in three months, that it had to be scraped off. Captain MacKillop seems to have been successful in attaching it, but to judge from the action of whitewash when applied to iron internally it is liable to corrosion under ordinary circumstances. Captain Coles also has a plan under trial on the Mortar Float, at Portsmouth, but it has not been long enough under experiment to report upon. Another preparation of lime was tried at the same time; the adhesion, however, failed.

The following is the specification of a patent taken out in 1862, and if it does not include the true specific, I know not what can:—

Mr. Chas. Duncan, in 1862, prescribes the following ingredients for a paint: marine glue, gutta percha, India rubber, shellac, copal, mastic, vegetable or mineral pitch or tar, resin, iodine, sulphur, creosote, asphalte, bitumen or coal-tar, in combination with one or more of the following: alumnia, quartz, slate, silex or flint, marble, sand, sandstone, cement, chalk, glass, emery, tripoli; white oxide of zinc, of lead, in proportion of a fourth or fifth of these powdered materials or pigments, to one part of the plastic substances.

To persons interested in this question, I may mention, there was a very excellent digest of the different plans for the preserving the bottoms of vessels, published in *Mitchell's Steam Shipping Journal* 1863.

I now propose to draw your attention to our wooden iron-clads by reading the following :—

Times, January 25th.

Our Portsmouth correspondent has received a letter from Malta relative to Her Majesty's ship "Royal Oak," from which the following extracts have been taken:—

"The 'Royal Oak's' bottom was found to be foul beyond all conception. Immense quantities of zoophytes, weed, and coralline flourished in the wildest profusion, and so hard had the little insects formed their habitations that nothing short of general scraping with sharp scrapers would remove the incrustations, the result of barely six months' accumulation. Whether this rapid growth is due to the Muntz metal with which the ship's bottom is sheathed, or the result of some general galvanic action, is hard to conjecture; but what another grand field for the experimentalists! The wooden sheathing over the armour-plating under water has been removed in several places for the purposes of examination, and the iron has been found to be in a perfect state of preservation."

The waters of the Mediterranean, from their composition, tend to foul the bottoms of all ships more rapidly, it is said, than the waters of the Atlantic, which may possibly account, to some extent, for the extraordinary deposits on the bottom of the "Royal Oak." Its formation has, without doubt, been quickened by the length of time the "Royal Oak" has lain in Malta Harbour; but our chemists would supply us with information of the highest importance if they could tell us the effect produced on the growth of these incrustations on the Muntz metal by the presence of the ship's armour-plating, and then discover an effectual remedy for it.

Standard, January 12th.

An Experiment with Iron-plating on Ships.—The French iron-clad frigate "Invincible" has just been taken into the dry dock at Castigneau, which has afforded an opportunity of judging of the efficacy of the system applied to that vessel for preserving her iron plates. A band of zinc, which, by isolating the electric currents, guarantees the plates from that green coating which causes injury, has transformed the nature of that vegetation, and, instead of a casing of marine herbs, there was found attached to the frigate's bottom a fine collection of corals.

The "Royal Oak."—On the water leaving the dock in which the armour-plated ship "Royal Oak" had been placed at Keyham on Friday, a most remarkable appearance presented itself, which created no small consternation amongst the authorities of Her Majesty's dockyard. The armour-plates adjoining, and in contact with, the copper sheathing were found to be eaten away by galvanic action, presenting a series of corroded holes running into each other, from half-an-inch to five-eighths of an inch deep. Some of the plates contained no less *than* 188 *of these, whilst none had less than* 40. Several detached holes are of an oval form, as though gouged out with a steel tool of all sizes, from that of the bowl of a salt-spoon to that of a gravy-spoon, and of equal depth, and some of the heads of the bolts had become recessed to the depth, size, and appearance of the bowl of a sauce-ladle. Numbers of the holes had run one into the other to the extent of five or six feet, five-eighths of an inch deep, and upwards; altogether presenting one of the most remarkable appearances ever witnessed. This ship has only been about eight months in the water. These holes and corrosion appear to have occurred wherever the red lead or under-coating had been rubbed or washed off.

The black fluid which still continues to ooze out between the armour-plates of the "Royal Oak" appears to come from salt-water leakage, which goes in between the butts, &c., gets discoloured by the tarred felt behind, and then comes out in a blackened condition. This state of affairs ought not to exist. It is evident that from whatever cause the black liquid arises, its presence inside the plates must tend to relax their hold upon the sides of the ship. It is surmised, first, that the fitting of the plates was not very exact when laid on, and, next, that they expand in heat and contract in cold weather, when the ends are sufficiently open to admit water. If this be the result of the experience of the "Royal Oak's" four months' trip in the British seas, what would be the effect of a three years' station in a warm latitude? The ends of the armour-plates are fashioned otherwise in France. There the outer edges of the plates nearly touch each other, while the inner edges retreat from each

other, thus leaving a hollow triangular space, the base being formed by the ship's sides. This space is caulked tightly with prepared oakum, and by this means all humidity is said to be excluded from inside the plates of French iron-cased ships; the caulking material expands sufficiently, when the plates contract, to prevent the water from entering.

The method taken to remedy the defect last described is as follows:—

It will be recollected that when docked in Keyham steamyard very serious effects had been produced by the galvanic action of her copper sheathing on the adjoining iron plates. Immediately afterwards it was determined to protect an intermediate space all round by the application of Hall's vitreous sheathing; but it was subsequently resolved to use the vitreous sheathing on one side, and a band of zinc on the other. The upper sheet of Muntz's metal, 14 in. deep, was therefore stripped from the port side, and a listing, 7 in. wide and 3½ in. deep, was cut into the ship. All the ends of the metal bolts were then cut off. A plank 2 in. thick was introduced into the bed of the cutting to prevent the ends of the bolts from coming into direct contact with the band of zinc, which was 1½ in. thick. It being fastened on the plank, the space made by the cutting became flush with the metal below and the iron plates above. It is expected that this band will prove a sufficient non-conductor to prevent the sheathing metal from producing any galvanic action on the iron plates. On the starboard side about 3,500 of Hall's vitrified plates have been glued or fastened on in a depth varying from 6 ft. under the stern to 2 ft. at the bow. There is a space, more or less, of about 2 in. between the upper edge of the copper sheathing and the lower edge of the iron plates; this space is left in order to cut off all connexion between the two metals, and was well payed with Hall's anti-fouling composition. The three lower tiers of vitreous plates are fastened on the wood with composition nails; those above are glued. The edges of the upper tier are covered by the teak-rubbing pieces. Some difficulty was experienced in fixing the plates under the quarters and near the sternpost, in consequence of the shape of the ship. The thinnest plates were selected for this purpose. Like the rest, they were forced on by hand-pressure only. Where galvanic action had eaten through the face of the armour-plates, the holes or pits have been filled with a mixture of Portland cement and Hall's glue. It was, however, previously necessary to expose these pits to the lengthened heat of burning charcoal, in order to extract from the iron the salt left by the previous admission of sea-water when she was in active service. To protect the stem a plate of vitrified iron was prepared, 4ft. 4in. long, 18in. deep, 19¼in. wide, and ⅝in. in thickness. This plate was brought home to the stem by vitrified screws (having enamelled heads) to within the sixteenth of an inch; it was then puddled below, and hot glue having been poured in above, the screws were driven in, and the plate was firmly fastened. It is understood that zinc is more liable to be injured by contiguity with Muntz's metal than iron, but the zinc band can be readily replaced in dock without damaging the ship. The "Royal Oak" will be accompanied by the gunboat "Trinculo," tender to the "Edgar."

But both these means having failed, as well as a complete trial of Hall's sheathing in the "Royal Sovereign," it has now been decided that our wooden iron-clads are to be sheathed with teak, and the "Royal Oak" has been so sheathed, with the results which I have read.

This wooden sheathing can but be a temporary measure, for abroad, the worm would cause leakage in a year, to say nothing of the working of the vessel, and these are vessels which are supposed to be able to keep their speed, without docking every six months.

This question of the insulation of the armour plates on wooden vessels appears to have baffled all attempts hitherto tried. Indeed, Mr. Hay, in a discussion at the Institution of Naval Architects (vol. iv., page 96, of Transactions), in answer to a question as to whether two or three feet interval of wood between the copper and armour would

prevent the copper being oxidised, and the bottom, consequently, foul; replies—"That if the wood between the copper and iron be covered with the patent waterproof glue, you might prevent galvanic action; but most wood, especially in sea-water, is a very perfect conductor between the two metals. I think the subject should be taken up by chemists, who should work at it for twenty or twenty-five years before you attempt to sheathe your armour-plated vessels." Mr. Reed, Chief Constructor of the Navy, says: "Iron ships can only be effectually sheathed by the interposition of a wooden skin."—Vide "Times," November 18, 1863.

The opinions expressed by Mr. Hay as to the value of wood as an insulator, are at variance with the course which has been taken with the "Zealous," "Caledonia," and others.

"CALEDONIA."

Times, August 13*th.*

The iron-cased screw has her sides prepared, somewhat like those of the "Zealous" at Keyham, to resist the galvanic action of the copper sheathing. The upper tier of sheathing has been removed, and vertical bars of iron, 3 inches broad by ¾ inch thick, have been bolted about 3 feet apart on the iron plating. On these bars a casing of teak, 3 inches thick, has been fixed, having grooves to receive the bars. The casing begins 2 feet above the load line, and runs down 7 feet, which is 5 inches below the iron plates. The new tier of copper sheathing runs up just high enough to overlap the teak 3 inches, so that there is a space of about 4 inches between the upper edge of the copper and the iron plating, and a distance of 4 feet 9 inches from the copper to the load line. For this depth in the sea the sides of the "Caledonia" present only the teak casing already described. The Lords of the Admiralty have, however, given orders that there shall be applied on a portion of the casing a new sheathing by Mr. Betteley, which he terms "union metal." Unlike yellow metal, which is a mixture of copper and zinc, Betteley's consists of copper on one side, and of a white metal like pewter on the other. The inventor contends that his sheets are so well adapted for iron-cased ships that if they were fitted directly on the plates no injury through galvanic action could arise. The results of this experiment will be looked for with considerable interest.

"ZEALOUS."

From 3 feet below the load line to 3 feet above, she is receiving a casing of teak planking which is 3 inches thick above and 4 inches thick below. To fix the planks to the plates, bands of iron ¾ of an inch thick were bolted on them perpendicularly, and grooves were cut in the teak to admit the bands. By this mode, fewer bolts were necessary, and the planks were considered better able to resist outward pressure. But the Controller of the Navy has thought it necessary to order the abandonment of the band system, and to have the planking bolted directly on the plates; the weakening of the planks by cutting the grooves is thus avoided.

But this insulation is of the material which the authority already mentioned states, is "a very perfect conductor between the two metals," so that to copper this teak would be dangerous without some other insulating medium, and, without coppering, will need frequent renewal. The cost is no small matter—£3,000 to do the "Royal Sovereign."

It is now a century since copper was first experimentally used as a sheathing for the bottoms of vessels, eventually to take the place, when it was proved successful, of lead, wood, and the numerous compositions with which ships up to that period had been sheathed and coated. On its first adoption, our vessels at that time being iron-

fastened, the bolts were found to be rapidly destroyed by oxidation, from the action of the external copper, and all the attempts at insulating the iron-bolts having failed, it was at last found necessary to use mixed metal and copper fastenings, in the construction of ships which it was intended to sheath with copper.

The substitution of iron for wood has placed vessels constructed of that material in the difficulty which wooden vessels experienced before the use of copper, and the means which have been tried to find a sheathing or coating which will preserve and keep their bottoms free from weed and barnacles, are as numerous as those we read of before the introduction of copper for sheathing wood.

There is hardly a substance, metallic or vitreous, which has not been proposed as a protective, and a comparison between the preparations for wooden vessels' bottoms before the use of copper sheathing, and those now intended to meet the difficulty of iron, are singularly alike. In 1765 there was a compound preparation "to preserve the bottoms of ships and other vessels, in which pulverised glass forms the chief ingredient," and I have already mentioned how many have been the proposals to apply glass in different forms to iron vessels.

Our ships, on which so many millions have been spent, are comparatively useless after a six months' cruise in a tropical climate; at an enormous additional cost, an increased speed of one mile per hour is gained at the measured mile, to be lost in six weeks after the vessels leave the dock. This loss of speed increases in a rapid ratio, and the steering power is proportionally effected. The proposal to build docks on all our distant stations, for our men of war to be cleaned in, does not meet the question, for the intention of sending a vessel from this country, is hardly for the purpose of putting her into dock for a fortnight, immediately on her arrival at her cruising ground. The building of docks is besides only half the affair; being built, they require fortifications, and a strong force to prevent their being destroyed, the existence of a dock alone, making the destruction of it an important blow, as long as vessels are dependent on it, for remaining efficient. They must be defended by regular fortifications, for the experience of what has taken place in America (if it were required), shows us how detached irregular works can be passed by iron-clads, and a ship, or even a boat's crew of the enemy might surprise a vessel helpless in dock, and destroy her; and an enemy's squadron, should the place not be sufficiently strong, gives the alternative of the destruction of the town, or of the docking and coaling of our own ships. The docks may do very well for peace, when it is not really of so much consequence whether a cruiser is a knot or more faster, but excepting at enormous cost, they will not meet the requirements of war.

In bringing forward the naval estimates last year, the Secretary of the Admiralty spoke in the strongest terms of the difficulties the fouling of iron ships caused. This year we are no further advanced, although a hope was then held out that something might be found.

From the first introduction of copper as sheathing, copper, and admixtures of copper, have displaced every other protection, and proved so far more effective, that notwithstanding its cost, and the additional

cost in construction entailed by its use, it has been universally adopted: from which data it is reasonable to assume, that copper is the best sheathing to apply to iron, provided a complete insulation can be obtained. The objection, of course, is the difficulty in preventing an action being set up between the two metals, but that does not at all prove the impossibility; and I hold if that can be satisfactorily accomplished, the risk (which is always advanced), attendant on a vessel striking the ground so heavily as to remove a portion of the sheathing, and leave the iron bare and exposed to the action of the copper, must be taken with the other chances of the sea; for from the time of a vessel leaving one port until her arrival at another, her whole career is one of risk, and the blow or grounding that would remove the sheathing, would necessitate a docking at the earliest opportunity.

In bringing my plan to your notice, I beg to state that I am only following in the footsteps of far abler men, skilled shipbuilders, and engineers of reputation, who hold the same belief in the possibility of coppering iron ships effectively, among whom I may name Messrs. Grantham, Jordan, Lancaster, Betteley, Mulley, and Muntz.

Iron vessels have been already coppered with an intermediate sheathing of wood. The "Iron Gem," on a plan of Mr. Mulley's; and Mr. Grantham, in the Trans. of Institution of Naval Architects, page 311, vol. 5, speaks of the beautiful appearance of the copper of an iron-built vessel sheathed on his plan. The question of copper over iron, will, like all other innovations, be tried in the commercial world by the touchstone of "What does it cost?" This, I believe, will receive a satisfactory answer from the figures I shall set before you.

But for vessels of war, after the enormous sums spent in their construction, it will be the false economy of a "good ship spoilt for a hap'uth of tar," if all means are not tried that gives fair promise of success, no matter at what cost.

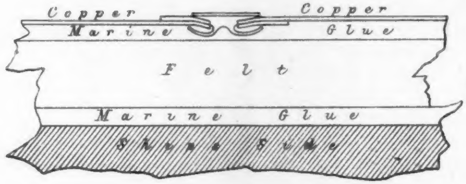
A Description of my Method.

1st. The bottom of the iron ship or armour-plate must be thoroughly cleansed, and when dry, coated all over with Hay's varnish, which is to be applied whilst hot.

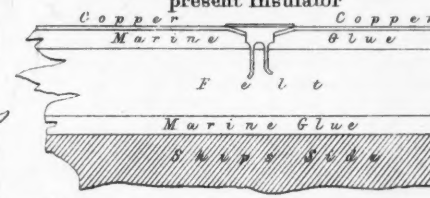
2nd. The bottom of the iron ship or armour-plate is then covered all over with a material such as felt, the edges and butts of which will be prepared, and will be lapped two inches over to insure a perfect insulator; and the felt, as an insulator, is made to stick or adhere to the ship or armour-plate by means of Hay's waterproof glue, in the following manner, viz.:—Place the felt or other material against the ship or armour-plate, and turn back a small part of the end of it, say about 12 inches, and then well saturate with the glue the part of the felt turned back; cover also the bottom of the ship or armonr-plate with glue, and as quickly as possible, whilst the glue is hot, place the saturated part of the felt against the glued part of the ship or armour-plate, and press it hard home; then proceed to glue small portions of the felt and bottom of ship or armour-plate, pressing the felt home quickly until the ship or armour-plate is entirely covered with the felt,

Rivet Nail.

Nail uniting Sheets.

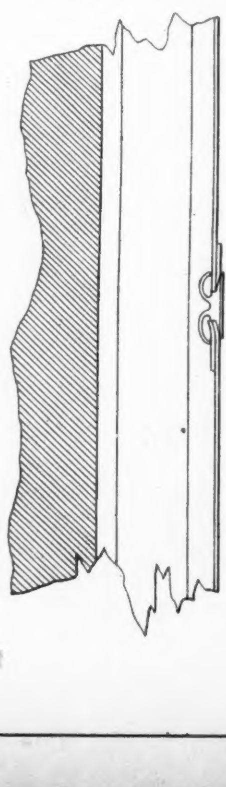


Showing that the Nail cannot penetrate to the Iron with the present Insulator



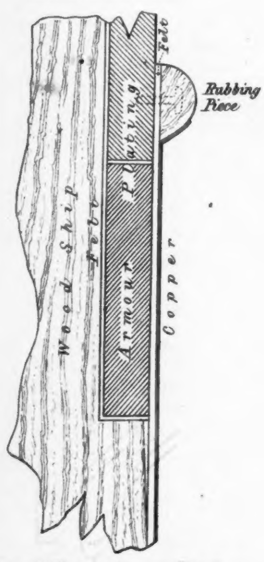
Full Size.

Section of Iron Ship.



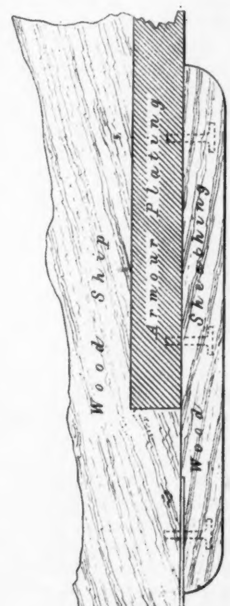
Full Size.

Section of Wood Ship Armour Plated.



Proposed Plan for Armour Plated Wood Ships shewing Armour Plates isolated by the Felt and Glue at the back of the Plates, as well as the front, and joint admitting of expansion and contraction.

Section of Wood Ship Armour Plated.



Method adopted on "Royal Oak" (vide report) which must impede the Ship.

J.R. Jobbins

which will then form a most efficient insulator between the bottom of the iron ship or armour-plate and the copper. When two insulators are used the outer should be applied to the inner in the same manner.

3rd. The outside of the insulator must then be covered with the glue in such parts as may be required to receive a tier of the copper, and proceed thus to glue parts of the insulator for tier after tier of the copper until the whole is completed, as it will be found much better to glue only such parts of the insulator as will be covered with the copper at once.

4th. After the nail holes are made in the copper and the burr removed, the copper must be then well covered on the side to be placed next the insulator with Hay's varnish, and the varnish should be put on whilst hot.

5th. The nails or rivets for securing the edges or butts of the copper together are prepared expressly for this purpose; and when placed through the holes, and struck with a light hammer, the points (being split and slightly turned out), coming in contact with the insulator, are opened and form a most perfect clinch.

6th. The felt or other similar material having been secured to the bottom of the iron ship or armour-plate, and forming the insulator, the varnish on the copper being quite dry, we proceed at once to secure the copper to the insulator, in the following manner, viz.:—Place some sheets of copper, either the upper or lower tier, against the insulator on the bottom of the ship or armour-plate, and temporarily secure them with small shores; then place the second tier either above or below, as the case may be, allowing the usual amount of lap for the edges or butts, and nail them with the prepared nail. Then place a hot plate as a backer over each sheet of the first tier, and force them home with a piece of wood backing and small shores, and when the edges and butts are nailed, secure the second tier; then proceed to place the third tier on the insulator, in a similar manner to those placed for the second tier, in a similar manner to the first, and proceed in this way for tier after tier, until the bottom of the ship or armour-plate is entirely covered with copper.

7th. The edges and butts are nailed together before the heat is applied, as the glue, when warmed, would fill up the nail-holes in the copper; and should there be by any chance any deficiencies with the nails, or that the nails do not quite fill the holes in the copper, the glue being heated outside, the glue fills up round the points and under the heads of the nails, and thereby causes them to be perfectly water-tight.

8th. The upper edge of the copper is secured with the ordinary coppering nails to a batten, which batten is secured to the bottom of the ship or armour-plate with screws; and above, or on the batten, a rubbing piece is worked, to prevent boats, &c., from injuring the upper part of the copper; and should the rubbing piece become injured in any way, it may be easily repaired or replaced without disturbing the copper: and this batten may be *either worked* perpendicularly or longitudinally.

I subjoin some copies of letters from officers and others who have seen my principle tried:—

ADMIRAL ELLIOT. H.M. Dockyard,

My dear Warren, *June 14th.*

So far as any plan for sheathing iron vessels with copper is concerned, I consider yours the best I have seen; and I prefer the felt as an insulator to wood, because it is more quickly applied, and more economical, and as effective as wood of an inch thickness, and not so bulky.

Extract from Mr. Cradock's answer to my letter relative to the tenacity of the Glue.

"In compliance with your request, I beg to inform you that on examination in dock "of the iron vessel lately sheathed with copper on your plan, at this yard, it was "found that the copper and felt under water adhered very firmly to the bottom, so "much so, that it had to be dubbed off with adzes, a proof of the tenacity, &c."

Report of Committee on Dockyards and Basin accommodation.

On foreign stations the provision of dock accommodation has become almost indispensable in consequence of the conversion of the navy into a steam navy. In former times it was the practice to heave ships down on careening wharves when in want of repair, but this expedient is not resorted to in the case of steam-vessels, as their machinery would be deranged by the operation, and, consequently, on stations where there are no docks of sufficient size, it is necessary to send them home whenever their bottoms require to be either cleaned or repaired. During their absence from their stations the cost of wages, victuals, coals, and of wear and tear is a dead loss, and this loss would be of constant recurrence in the case of iron ships, as it is necessary to dock them for the mere purpose of cleaning their bottoms at least four or five times in the course of the ordinary duration of a commission.

COMPARATIVE STATEMENT OF CHARGES BETWEEN DOCKING AND PAINTING AN ARMOUR PLATED SHIP OF 3668 TONS.

COST OF DOCKING AND PAINTING.

Present Method.	£	s.	d
Docking and undocking	100	0	0
Hay's Patent Protective Varnish	74	15	0
Ditto Anti-fouling Varnish	107	18	0
Labour	55	18	4
First half year's expense	338	11	4
			2
First year's expense	677	2	8
			6
Two commissions, or six years' charge	4062	16	0

N.B.—Items not included in the above statement but properly chargeable.

1. Wear of ship's bottom when scraped and cleaned in being prepared for painting, ALSO THE INJURY DONE TO THE HEADS OF THE RIVETS BY SCRAPING.
2. Officers in attendance, docking and undocking.
3. Steam vessels in ditto ditto.
4. Unloading and loading stores.
5. Stowing and unstowing stores.
6. Wages of unemployed crew.
7. LOSS BY REDUCED RATE OF SAILING.
8. Loss of service of ship, officers, and crew, while in dock having the bottom scraped, varnished, and dried, at 14 days each, SIX MONTHS or SIX MONTHS in the six years.

} *

* These figures are not filled in from a desire of not over-stating the gain by Warren's Patent.

Expenses of Sheathing by Warren's Patent.

Cost of copper, new, £1728 7*s*. 6*d*. .. .. / Returned to store £1305 17*s*. 8*d*.	422	9	10			
Cost of rivets	186	13	4			
Material for preparing the ship to receive the copper, including the Royalty for the use of the patent ..	1392	10	0			
Labour	273	11	6			
	2275	4	8	2275	4	8
Advantage in sheathing in six years				1787	11	4

Cost of Coal.—"Megæra."—Burns at full speed 45 tons of coal per day, this at 10 knots per hour should carry her 240 miles, but her loss being 3 knots per hour this quantity of coal will carry her only 168 miles. Coals, at lowest price, £2 per ton, her cost per diem is £90, and the loss on that by foul bottom £23 per day. This is at the price paid for coal in peace, it would more than double itself in war.

Against this the loss of time to a sailing-vessel returning from China or India, and the increased risk, not to say hoplessness, of a vessel so foul, and steering so badly, getting off a lee shore.

Captain Madden, "Megæra," Devonport, *February 24th*.

My dear Warren,

The "Megæra" was docked in May last and not re-docked till the end of January (nearly eight months), and I found her speed very much diminished about August. I think in that time she must have lost $1\frac{1}{2}$ knots an hour, and about the end of December we lost at least $2\frac{1}{2}$ or 3 knots. With a strong gale, 3 reefs in topsail, and reefed foresail, scudding with the screw up, she only averaged $7\frac{1}{2}$ knots, when, if her bottom had not been foul, she would have done $10\frac{1}{2}$ or 11. Her steerage was also very much affected. Three days after we got into dock the smell from the decayed shell-fish was almost unbearable, in fact she was like a mussel-bed. Coated with Hay's and McGuiness' compositions, one on each side. We found Hay's the best, but both seemed to me totally inefficient.

April.

Report of Dockyard Officers at Portsmouth.

Sir,

In obedience to your orders of 5th inst., we beg to state that the whole of the copper sheathing has been removed from the bottom of No. 145 mortar float; and, after a careful examination of the bottom, we cannot discover that it is at all injured by oxidation or any other cause, but it is to all appearance in the same state as before the application of the copper by Captain Warren. We found, on removing the copper, that the felt adhered very firmly to the iron, and had to be dubbed off by shipwrights to remove it from the bottom, except in a few instances where small patches of very slight oxidation have taken place, through the want of the adhesion of the felt to the iron in those places; but the oxidation is so slight as to have caused no apparent injury to the iron.

These oxidized places appear to have been produced by the rivet nails having penetrated the insulator, thereby allowing the water to have access to the iron of the bottom, in such places where it was unprotected, through the felt not having perfectly adhered to it.

H. C.
A. S.
E. W.

An extract from an American paper to show that our neighbours are no better off than ourselves :—

DIVERS.—The Port Royal correspondent of the *Baltimore American* gives an account of the operations of the divers employed to clean the bottoms of the Monitors. He says that the principal diver—appropriately named Waters—is so used to this work, that he has become almost amphibious, remaining for five or six hours at a time under water. The work is very arduous. The diver sits upon a spar lashed athwart the bottom of the vessel, so arranged as to be moved as the work progresses, and with a scraper fixed to a long handle works on both sides of himself as far as he can reach. The mass of oysters that become attached to the iron hulls of one of the Monitors, even during one summer here, is immense. By actual measurement it was estimated that 250 bushels of oysters, shells, and sea-grass were taken from the bottom of the "Montauk" alone.

In the construction of composite ships with iron frames, I believe, a great economy would be found by sheathing on this plan; the destruction of the bolts, by the approximation of the copper, be avoided; and iron-fastened vessels coppered more effectually by the interposition of a waterproof medium. The application of copper, by adhesion, on the bottom of a wooden vessel, from the light line to the keel, would remove all possible risk of leakage, and injury to cargo from damp, the close adhesion would prevent oxidation internally, and the external waste be reduced, from the sheathing being dressed on a smoother surface.

In conclusion, I would ask what alternative has been proposed that promises to meet the difficulty excepting an application of copper sheathing. There is risk; but what is done without it. The powder in the magazine is merely isolated by a sheet of glass from the light-room, but that risk is preferable to fumbling in the dark; and, to quote the words of Sir John Hay, when referring to this subject in the House, "I believe if the talent and ingenuity of the country were appealed to, there is no doubt the practical difficulty could be overcome."

ANTI-CORROSIVE AND ANTI-FOULING COMPOSITIONS FOR IRON SHIPS.

By F. N. GISBORNE, Esq., C.E.

GENTLEMEN,

Before submitting the following brief observations relative to anti-corrosive and anti-fouling compositions for use upon iron ships, allow me to acknowledge the valuable assistance rendered me in the preparation of this paper by my friend Mr. W. H. Walenn, a gentleman who has rendered great service to the public by condensing (to order of the Patent Law Commissioners) all the various patented inventions appertaining to electric science. Mr. Walenn is himself the patentee of a very ingenious method for coating iron with copper, and from his know-

ledge and experience was well qualified to aid me in rendering this paper instructive as well as interesting and reliable.

The introduction of iron in lieu of wood as a material for ship-building has raised several practical questions for the consideration of the shipwright, engineer, and man of science.

The stability of the structure, exposed as it is to strains of peculiar character, the adjustment of the magnetic compass and other difficulties which have arisen have all been more or less successfully dealt with, and now we have one more desideratum pressing seriously upon the attention of all interested in naval architecture. I allude to the subject of the present paper, "Anti-corrosive and anti-fouling compositions for the bottoms of iron ships."

A similar question formerly arose in regard to wooden ships, but the experience of years has been so well directed to the preservation of all ligneous structures when immersed in sea-water, that but little anxiety is now felt respecting their durability. That this was a matter which deserved and received much attention from our ancestors is abundantly manifested by the early date of patents having such an object in view, for we find that although letters patent were first granted by James I., 1617, and then most sparingly granted, the thirty-second patent was secured to William Beale, in August, 1625, for "Preserving ships from hurt by the sea-worme or barnacle by means of certain cement or dressing."

The introduction of *iron* as a material for ship-building is of comparatively recent date. It appears, however, that a canal boat of iron was built 1787, and that iron canal boats were in general use 50 years ago. The Horsley Iron Company, of Tipton, Staffordshire, built the first iron sea-going steamer, the "Aaron Manby," in 1821. Mr. Grantham navigated an iron steamer on the Shannon, in 1824, and from about 1838 to 1840, iron vessels began to come into general use. The apprehension excited in the minds of shipwrights and shipowners respecting the want of durability of iron in sea-going vessels, together with the heavy item of current expenditure for keeping iron vessels in serviceable repair, are so great that even now, many assert that wood-built ships maintain their superiority. Only last week, when I had the honour of reading a paper at Glasgow before the "Scottish Shipbuilders' Association," upon *Electric Signals*, there were many advocates for composite ship-building, *i.e.*, iron frames, planked and coppered, the great objection raised to all iron being the great cost of cleaning in foreign ports, and the great falling off in speed from the rapid growth of animal and vegetable matter, even upon the best anti-fouling compositions known.

The corrosion of the iron wherever the sea air and sea water can act conjointly upon it is quite a secondary consideration, as compared with the annoyance and loss occasioned by the rapid fouling of iron ships, more especially when at anchor in tropical climates; and it is this chief difficulty which has engaged the attention of so many aspirants to fame and fortune.

As a matter of history, it may be mentioned that the ingredients of the paints used for the preservation of wooden ships in all the earlier

patents were principally pitch, tar, resin, and sulphur, while the idea of *poisoning* the "sea-wormes" appears to have entered the minds of inventors about the year 1737. Metallic sheathing, however, either with or without a layer of felt between it and the wood, was at last the plan generally adopted.

The inventions that relate to the protection of iron ships from corrosion and fouling are extremely varied in the means employed to effect such purpose. In the early part of this century, Sir Humphrey Davy proposed, as a preventative against oxidation, the attachment of sheets of zinc to all iron exposed to sea water relying upon the galvanic action of the zinc and iron. The result, however, of this arrangement proved that the iron was only in part prevented from rust, while its surface became even more attractive for the growth of seaweed and crustaceæ.

Some inventors rely entirely upon pitch and tar, and their mixtures with oleaginous and other organic substances.

Paints, properly so called, are employed by others either with or without a previous preparatory coating.

Many experienced shipwrights are of opinion that nothing surpassed ordinary red lead, or white zinc, mixed with boiled linseed oil; but these paints do not entirely prevent rust, while they permit the growth of weed and barnacles, and require very frequent renewal, and consequent dock expenses. To stop short, therefore, in the enquiry for an anti-corrosive and anti-fouling paint at this early stage of our experience, would be to announce our belief in the impossibility of a perfect solution of the question, and would be utterly unworthy of the nation which is destined to be the greatest iron ship-builder in the world.

Other inventors again apply cements, vitreous compositions, and even vitrified surfaces to the vessel; Jeffrey's marine glue, or other glue in one instance being the means of attachment of vitrified iron plates. The application of Sir Humphrey Davy's metallic zinc plates is again revived, either as a total or partial covering, or with varieties in detail, and to this basis a large class of inventors have turned their attention; others again interpose a layer of wood between the iron and the zinc plates with their fastenings, while others use felt in lieu of wood for the same purpose. Amalgamated zinc plates are another variety of the same general principle, while several inventors propose to encase each iron plate within a thick coating of other metals.

Mr. W. H. Walenn has been particularly successful in encasing iron with copper or brass by galvanic action, the latter metals being precipitated upon the iron to any thickness required.

No less than 57 patents, exclusively for paints for iron ships, are now in print, since the first protection was obtained in the year 1831, for an anti-corrosive and anti-fouling pigment for the bottoms of iron ships.

In some of these the composition consists of a mixture of salts of the metals with sulphur, or other readily-melted substance, and is applied hot. Gutta-percha, india-rubber, and other gum compositions have their enthusiastic supporters. Pitch and its combinations with organic bodies appears from its cheapness and ready application to

satisfy a large number of inventors. The *favourite* idea, however, appears to be a revival of the old shipwright's notion of poisoning the "sea-wormes," accordingly, arsenic, antimony, sugar-of-lead, verdigris, croton oil, cyanide of potassium, mercurial ointment, asafœtida, and strychnine figure in the list of material weapons brought to bear against the unconscious barnacles, and their tendency to growth (under difficulties) in contact with submerged iron. Essential oils, powdered glass, powdered metals, plumbago, and other forms of carbon, metallic oxides, and gums, enter into the composition of the paints put forth by a great proportion of aspirants to fame in this department of practical science. One patentee advocates the use of guano; two inventions relate to the use of oil, constantly expressed from pores in the sides of the vessel, so as to ooze out over the submerged iron plates. In one of these the oil is combined with arsenic. Clay, lime, and other mineral earths are announced by some inventors to form, in combination with other ingredients, a specific for the evils complained of.

Among all these numerous patents there are, however, some few in general use which are of sufficient importance to merit particular notice.

Mr. William John Hay, Admiralty Chemist at the Dockyard, Portsmouth, has obtained two patents. The first, under date February 1st, 1858, consists of a mixture of Trinidad pitch or asphaltum, vegetable tar, and naphtha, to which caoutchouc, creosote, and turpentine may be added. The second patent, under date November, 1861, is based upon the use of protoxide of copper, ground and boiled in linseed oil, until reduced to suboxide, to which silver or its oxide may be added, with naphtha or turpentine as a drier.

It is wisely recommended that a *protective* coating be applied to the iron before this anti-fouling composition is used.

Green's and Peacock and Buchan's paints are also among the few best known to commerce. I am not aware of the basis of these paints, but am informed that arsenic and carbonate of copper are respectively combined with them.

Jeffery's marine glue has been used alone, and in connection with other inventions. The patent has expired some years; the composition is based upon caoutchouc and shellac.

McInnes has also two patents, the first under date June, 1854. This composition consists of pale yellow soap and sulphate of copper.

That of the 2nd of October, 1856, relates to a composition containing powdered emery and shellac, dissolved in spirits of wine and mixed with resin, castor oil, and ammonia, to which ground glass, sand, and cement may be added.

Dr. White patented, in 1863, a pigment composed of tallow, oil, and powdered quicklime.

The object of the foregoing and most generally known inventions, is evidently based upon two principles, viz., either to *poison* crustaceæ and marine vegetation, or to offer a continually changing surface of so unstable a nature, that neither shell fish nor weed can take permanent hold of their first resting place.

This latter intention I believe to be the *first* step towards a solution of the question. All of the foregoing inventions are now before the public, and have met with more or less success in various climates, and under varied circumstances, for it is a curious fact that the results obtained from avowedly the same composition, will prove either a "success" or a "failure," under apparently precisely similar application, and when exposed to the same run of ocean.

It is therefore with the utmost deference to the ingenuity and experience of other inventors, that I now state the component parts of my own composition, and endeavour to offer a reasonable explanation of the grounds upon which I rely for success.

My patent is dated October, 1863, and was secured only after a twelvemonth's private trial of its capabilities. It consists of a combination of quicksilver, vermilion, oxides of lead, powdered flint, glass, litharge, and boiled linseed oil, in such proportions and so triturated and ground together, that the large proportion of quicksilver used, namely, one-fourth, and in some instances one-third of the entire weight of materials, disappears, and still more curiously remains in suspension throughout the entire mass months after mixing.

The theory, and I may now add the proved results of the foregoing combination is as follows:—

First. That the paint is of such consistency and "body," that it interposes a sufficient thickness of material between the sea water and iron surface, as will stand ordinary wear and tear, and at the same time is in some degree a waterproofing composition.

Secondly. That the attachment of the paint, owing to its nature, is perfect when applied to a clean and dry surface of iron.

Thirdly. That the chemical action of the paint is not necessarily *poisonous*.

Fourthly. That the character of the pigment enables it to evolve an element which is obnoxious to animal and detrimental to vegetable existence, and that in so remarkable a manner that not only is the iron partially free from barnacles and other crustaceæ, but that *not one* attaches itself to iron thus protected.

Fifthly. That the paint itself slowly wears away, thus continually preventing an unstable surface for anything inclined to fasten upon it, and also at the same time exposing fresh chemical agencies to produce the effect hereinafter explained.

Lastly. That in case of any slight scratch or abrasion in the coating, the exposed iron is, to a considerable extent, protected by the adjacent composition.

In all ages, and for various purposes, quicksilver forms illustrations of a remarkable character. Some philosophers believe that the Egyptian magicians employed it when Moses defied them before Pharoah to cast down their rods, and to cause them to become serpents. Dœdalus is reported to have moved a wooden statue of Venus by means of a stream of mercury, while at the present day mercury is employed to show the heat and weight of the atmosphere, and to cure diseases. The advance of physical, electrical, and chemical science is greatly due to its adaptability to various purposes. The

mercurial trough for the collection of gases that are soluble in water, the use of mercury as a reflecting medium in optics, its conductability of heat and electricity, its fluidity at ordinary temperatures, its high specific gravity, its power to dissolve metals, and its easy volatility, present a combination of properties that is rarely met with in an isolated elementary body. One other property of quicksilver which enables it to be employed as a metallic paint is its singular affinity for oleaginous substances, and it may be stated here that it has strong sympathetic and anti-pathetic tendencies, which are not only manifested by chemical affinities, but by affinities not less strong (although their display is more rare), of which physical science takes especial cognizance. The power of mercury to unite or amalgamate with metals in general, and the repellant action of mercury on iron and platinum are illustrations respectively of these sympathetic and anti-pathetic tendencies.

The forces by which the particles of bodies are held together, are—

Firstly. "Cohesion;" by means of which particles of an identical character form a mass.

Secondly. "Adhesion;" by means of which particles of different kinds form a mass, each constituent particle retaining its individual properties.

Thirdly. "Chemical affinity;" in which particles of different kinds unite to form a mass, the properties of the resulting compound being of a totally distinct character from those of its constituent particles.

It is to the second development of force, "adhesion," that the attraction or affinity of mercury for oleaginous substances belongs. This adhesive force is much increased by the increase of surface of the bodies brought within its influence. There is every reason, in fact, to believe, that adhesion increases in direct proportion to the increase of surface. By pulverizing a substance, the surface is increased to its maximum in proportion to the weight of the substance. Dr. Miller calculates that if a cube of one inch in the side is subdivided into a number of cubes, each of which is $\frac{1}{1000}$th of an inch in the side, the adhesive force is increased 1,000 times. The size of the globules of the paint now under consideration is so minute that they are undistinguishable by the naked eye, the quantity of light which they collectively reflect being so small as not to interfere perceptibly with the colour imparted to the paint by its other constituents, although, as before stated, there is 30 per cent. of metallic mercury in it. The average diameter of the globules is ascertained to be $\frac{1}{10000}$th of an inch, and the adhesive force is increased by communition in comparison with that of a sphere or globule one inch diameter, 10,000 times. The natural adhesive power of mercury for oil, and the minute degree of fineness to which it is reduced in this paint, accounts for the singular fact that whilst the powdered flint glass employed to divide the globules in the first instance, when manufacturing the paint, is partially deposited at the bottom of the containing vessel if the paint be at rest for some time, yet the mercury is retained in suspension with little or no tendency to separate itself from the other ingredients of the composition, thus neutralizing the powerful effect of the attraction

of "gravitation" upon mercury by the still more powerful effect of the attraction of "adhesion" of the mercury for the boiled linseed oil in the paint.

Other means besides attrition with oil are known of comminuting mercury and bringing out its adhesive force for certain other substances. Some substances cause the development of the force to a greater degree than others. When pure mercury is shaken with water, ether, or oil of turpentine, or rubbed with sulphur, sugar, chalk, lard, conserve of roses, &c., &c., it is very highly comminuted. If metallic mercury is precipitated by adding an aqueous solution of proto-chloride of tin to an aqueous solution of bi-chloride of mercury (corrosive sublimate), the precipitate takes several hours to subside; and if running mercury is agitated in dilute sulphuric acid in contact with a few crystals of sulphate of copper, electrolytic actions cause hydrogen gas to be given off at the surface of the mercury, while the mercury assumes the form of froth.

The uses of comminuted mercury have, until lately, been almost entirely confined to its therapeutic action upon the human system. The mercurial ointment, bluepill, and "pulvis hydrarg cum cretâ" of the pharmacopœias are instances of its application as a curative agent. In contradistinction to this, it may be noticed that Brande in his "Chemistry" states that it is probable that mercury, administered to the human system in mass, is medicinally inactive. An inventor finds another use for the compound of mercury with grease, by employing it to insulate those parts of the zinc plates of galvanic batteries that are not directly opposed to the negative plates.

As the mercury exists in my paint, there can be no effect produced upon the marine vegetable and animal deposits, such as barnacles, by the agency of any *poisonous* substance, but other experimenters and patentees have sought to obtain the desired results *by poisoning* marine animals and plants, *such being an impossibility*. Professor Wilson tried many careful experiments in proof of such assertion. He mixed the most subtle poisons known with ordinary ship's paint, and after barnacles of large size had grown upon the wood and iron thus protected, he boiled the fish, and with such food poisoned many animals within a brief period, thus proving that mollusks could imbibe the poisonous matter into their systems without detriment to their own existence. The Chairman of the Scottish Shipbuilders' Association also stated the other evening that an iron plate had been coated in squares with four of the best known anti-fouling compositions, and after some months' submergence was raised for examination. The plate was covered with barnacles, and, ludicrous to relate, the biggest fellow among them had fastened in the very centre of the plate covering the junctions of the four paints, as if to taste and defy the villainous bait laid for himself and compeers.

With such testimony before us, I think we may very fairly conclude that henceforth we must look to other agency than *poisoning* as the basis for anti-fouling compositions. In my paint I have endeavoured to obtain the desired result by the combination of two theories, one being the gradual wearing away of the paint from its surface by the action and attrition of moving sea-water, and the other from electric action

upon the delicate organisation of incipient life in either animal or vegetable matter, always bearing well in mind that such chemicals are made use of, as shall in no possible manner give rise to galvanic action at the expense and to the consequent detriment of the very material we seek to protect. It is upon the latter reasoning that objection arises to all paints containing copper, which is in itself an element of destruction to the iron plates of a vessel afloat; this arises from the tendency of the salt, or precipitate of copper, which gives body to the paint, to become decomposed and to yield up its copper in the metallic state, and in contact with the iron. These observations apply to any paints in which metallic substances electro-negative to iron in sea-water are made use of.

It is only after numerous experiments, in which I have been materially aided by my coadjutor, Mr. John Hughes, in many of our part works, and during which we have had to deviate from the specification of my patent, that successful results have been obtained; and it is a curious fact that even with the same weight of mercury employed, slight additions or subtractions from our present formula most materially affect the lasting value and effects of the composition.

Twenty years ago, when in the Gulf of Mexico, the Captain of the vessel I was in tried experiments with mercurial ointment taken from his medicine chest, with little or no effect upon crustacea. The idea then was to *poison* or salivate the shell fish, and, lately, Captain R. Johnson has taken out, but since abandoned, a patent in which he tried the effect of one-eighth part of mercurial ointment and one-eighth part powdered arsenic in his composition.

Before an inventor in this country can' obtain aid to introduce a new material he finds it necessary, in the first instance, to obtain a "patent" or "protection" (the latter frequently proving an expensive misnomer). This, as you are aware, I have done, and I have laid before you the main features of the composition therefrom; but the secret of manufacture, &c., which is only of personal interest, I feel sure you will readily excuse my entering upon.

From trials, which have extended over twelve months each, it appears that plates and vessels coated with this paint are as free from animal or vegetable growths when taken out of the sea-water as when placed therein, while the material has worn away but maintained its virtues to the last film. All testimonies tend to show that not only is freedom from barnacles secured (even though the coated surfaces are stationary in sea-water at places most favourable to their growth), but that the grass overhanging the upper edges of the sections on ships allotted for experiment is dwarfed in growth and of lighter colour than that which is contiguous to my composition.

There is clearly, therefore, some other active agent at work, which I thus explain: Electric or galvanic action can be excited between two fluids of different nature, and one metal as between two different metals and one fluid.

The quicksilver is the metal which I employ, the salt water one fluid, and the acids peculiar to crustaceæ and marine vegetation the other fluid.

You thus create, under the fish or vegetable germ, as many galvanic

batteries acting upon their extremely delicate organization, as there are minute points or globules of mercury in contact with them. There is also a certain amount of resilience or elasticity in my paint which I attribute to the film of oil between the mercury and iron remaining moist, and thus in itself protecting the iron to a certain extent; this is also a valuable adjunct in assisting the mercury to flow over and protect the iron in case of any slight scratch or abrasion, and forms one of the peculiar properties of the paint. The attachment of the mercury to the naturally repellant iron by aid of the oil is thus a good example of the adhesive force already explained.

Such, Gentlemen, is the theory of my composition, and, in conclusion, I will call your attention to one or two certificates which you can substantiate to your own satisfaction, bearing in mind that from the varied alterations in the course of our manufacture we have made errors, since discovered and corrected, which would have been more or less discouraging had we not proved that the basis of the invention was unquestionably correct.

The officers of the steamer "Caroline," running in the Mediterranean, pronounced my sections after twelve months trial, during which time the rest of the vessel was three times painted with other paints, as clean as when first coated with the composition. This steamer is now owned by Mr. Henley (the well-known electrician) who will confirm their statement. I believe she is at anchor in the Thames at the present time.

Captain Jackson, Lloyd's agent at Milford Haven, thus writes of the plate now before you. "This plate was submerged in Milford Haven waters for over six months, and at the termination of that period was found to be worthless on the red lead side; but perfectly free from corrosion, weed, and barnacles on your composition side," a similar result was reported of a plate ten months submerged, and he adds, "You may depend upon the practical value of this composition, and you may refer shipowners to my experience in almost every patent composition extant. I have seen none that will compare to the one now referred to." Similar evidence has arrived from Malta, while lately our experimental vessels have been arriving from all parts of the world, and the owners are purchasing the composition largely.

Among other successful experiments I may mention the "Eastern Province," of the Diamond Steamship Company, although the paint used upon that vessel and one other belonging to the company was among our experimental errors, by which the addition of peroxide of iron reduced its *lasting* though not its *effective* qualities fully one-half. The "McGregor Laird," of the African Steamship Company, also painted with the peroxide of iron mixture, came in clean, and the "Aleppo," belonging to the Cunard Mediterranean fleet, was last week docked and found clean.

I have now the pleasure to add that, after some successful experiments in the Medway, we have executed an order from the Lords of the Admiralty to paint Her Majesty's ship "Valiant." This vessel we have coated upon one side only, Mr. Hay (Admiralty Chemist) and another patentee having the other side for competitive trial.

We are still experimenting, with a view to making our paint last over a longer period than twelve months without detriment to the qualities which it now possesses.

In conclusion I may add, that although necessarily costly from the expensive nature of its component parts, *i.e.*, costly per cwt., yet it spreads over so large a surface that it is not beyond the pale of commercial sale, while, should continued trial prove it to be all that we believe it to be, the extra speed, and immense saving of time, and dockage expenses will make it a boon to all iron-ship owners, and a valuable adjunct to our naval superiority.

Mr. J. W. Hay, H.M. Dockyard, Portsmouth: I am a stranger who has been invited here, and I may, perhaps, be allowed to clear up a point which has been mooted by my friend, Captain Warren. In the *Transactions of the Institution of Naval Architects* an error of the reporter has occurred, which I never saw until the *Transactions* were in my hand. For any scientific purpose, or for the gentlemen who are in this room, I do not consider it necessary to explain that error; but I wish to clear away any imputation that might be put upon my professional character. When the meeting was on the point of breaking up, and the room was consequently in a state of disturbance, the question was asked, "Mr. Hay, what effect would three feet, five feet, or one foot of wood have in stopping galvanic action between Muntz's metal and armour plating?" Knowing, as I did, that Muntz's metal had been placed on ships, and that the only man who ought to have been consulted had not been consulted, and this was a professional officer that asked the question, I stated that before they sheathed an iron-ship or an armour-cased ship, they should have consulted the man who had been devoting his energies from twenty to twenty-five years to the service, in a chemical point of view. That was my remark; but in the confusion occasioned just as the meeting was breaking up, it was misunderstood, and I pardon the reporter. I did not consider it necessary to explain the error; indeed, I never thought any gentleman would chaff me with the ridiculous imputation that we must wait twenty or twenty-five years before sheathing an iron ship, when we do not know from hour to hour that we may not require the ships in action. I beg simply to explain this, because I do not wish gentlemen to go away with the notion that I could have made such an assertion. I am sorry that Captain Warren should have alluded to the newspaper reports respecting one or two ships. The "Resistance,"—unfortunately, we only get part of the information,—happened to be coated simply with a protective varnish. She went out to Malta, and at Malta she was "hogged" without disturbing the composition in any way that had been put on eight months before. But being in dock, it was considered necessary, owing to where the chain cable had rubbed and other places, to coat this ship's bottom. But as there was nothing at Malta suitable for the purpose but the protective varnish, the protective varnish was alone put on. The protective varnish consists simply of asphalte, pitch, and naphtha, which we never for one moment consider will prevent anything like fouling. This ship was docked again in six months. She never had Hay's composition put on her. And as to the report about the "Recruit," it is beneath me to notice it. I regret that it should have been necessary to make these remarks; and thank you for the patience with which you have listened to me.

Captain Craigie Halkett: As I am one of many individuals who have taken an interest in the discovery of a coating for the prevention of fouling in iron ships, I should like to say a few words in connection with the subject under discussion. I do not propose to take up the question of sheathing brought forward by Captain Warren; nor shall I attempt to remark at all on many of the coatings which at various times have been suggested; but I shall limit myself to the consideration of certain points in reference to the invention of Mr. Gisborne, comparing his invention with one presenting many analogies to it, in which I have taken no small amount of interest. During the period in which Mr. Gisborne was carrying on his experiments

for the purpose of proving his invention, there were experiments going on in the neighbourhood of Edinburgh, which I had a good deal to do with. Those experiments were quite independent of his, and were carried on in perfect ignorance of his proceedings. They were conducted in a systematic manner, and showed, after the trials of a number of substances, that certain compounds of mercury were best able to answer the purpose of preventing both fouling and oxidation. My reason for wishing to say a few words here to-night, is because the patent that I am about to allude to, is very nearly connected with Mr. Gisborne's, and is, to a certain extent, an opponent of his. With reference to the oxidation of iron, we all know that mercurial ointment has been used many years for the prevention of corrosion. Every Ensign who goes out on foreign service, finds a jar of mercurial ointment in his gun case, put there by his gun-maker, to be rubbed with a rag over his gun or rifle on any occasion when the weapon is to be exposed to damp, especially to sea air or salt water. The results of the experiments before alluded to, formed the basis of a patent taken out by Mr. Francis Cruickshank, of Edinburgh. I will name the three compounds of mercury which he employs; but before doing so, I would briefly state certain principles which were deduced from the experiments, as they have a most important bearing upon the question at issue. Firstly, I would state that a coating, in order to protect a vessel effectually from fouling, must contain some substance or substances which shall excite deleterious action on animal and vegetable organisms. Secondly, that the chosen substance shall be insoluble, or so slightly soluble that, while acting energetically on the living organism, the action of sea water in contact with it shall be very slow. Thirdly, that the deleterious substance or substances shall be fixed to the vessel by means of a medium of sufficient hardness and toughness to resist the friction which a vessel necessarily encounters in passing through the water. In support of these principles, I may state that the experiments I have been watching near Edinburgh, have clearly shown that the animal and vegetable organisms giving rise to fouling, are remarkably affected by contact with surfaces coated with various metallic poisons. In the case of the large majority of these, the absence of insolubility renders them altogether useless. The substances which are in the composition of Mr. Cruickshank's coating, in a wonderful degree possess the qualities upon which I have insisted. They are energetic poisons, not apt to vary in their composition, and when applied by means of a suitable coating or paint to iron plates, they have been found to protect them from fouling in the most effectual manner, whether the said fouling be caused by animal or vegetable life. I will now mention the three compounds of mercury in Mr. Cruickshank's patent:—First, white precipitate of mercury; second, oxichloride of mercury—a term which includes various definite chemical compounds of corrosive sublimate and protoxide of mercury; third, the red oxide of mercury. I may add, that the powers which these ingredients possess to prevent fouling, will, I feel confident, prove valuable to the Admiralty and to the mercantile marine. Now, allow me to say a word upon the principles upon which Mr. Gisborne's invention is said to rest. I am far from saying that I think Mr. Gisborne's coating is not a successful one. I believe it is a successful one. It has been alleged that the action of Mr. Gisborne's invention is purely mechanical, by means of electric action; and that this action is noxious to animal and vegetable life. Whatever action Mr. Gisborne's coating does possess, I am satisfied that it is explained by the principle I advocate. I am firmly convinced that the reason why it is so far successful, is because the mixing of his pure mercury with a greasy matter brings about a certain amount of oxidation in his metallic mercury, and it is *that oxidation* of his metallic mercury that is deleterious to animal and vegetable life. Mr. Gisborne states that the electric action is affected by two fluids and one metal. He states that the acids of the juices of the animal and vegetable life are necessary to produce this electric action. We may naturally presume their adhesion and presence are necessary; but Mr. Gisborne keeps these organisms entirely off by his coating. The simultaneous presence and absence are not easy to comprehend. Metallic mercury possesses no poisonous action. When combined with other elements, however, it gives rise to compounds possessing the most poisonous properties. When mixed up ultimately with greasy matters, for instance, a very small quantity of mercury is oxidised; and by this oxidation, the

physiological action of the metal becomes altered, because a substance has been procured which is poisonous, and almost, if not entirely, insoluble in water:—a substance, therefore, possessing properties which fit it for the protection of vessels from fouling. I am aware that it will be objected that such powerful poisons as arsenic and tobacco, exert no action upon the animals which are, to a great extent, the cause of fouling. I meet this by saying, that because some poisons do not act injuriously upon marine animals, it is most illogical to argue that none can affect them. Innumerable instances occur of individual animals and plants becoming affected by some poisons and not by others; and it is an incontestable fact, that the substances which I have named, not only protect iron from fouling, but actually are poisonous to marine animals. You will, therefore, admit that a coating which contains a definite amount of such insoluble and poisonous substances must be preferable to one whose action depends on the tardy and incomplete oxidation of metallic mercury—an oxidation which will vary with the mode of the preparation of the mixture, and with the temperature, &c. These were the reasons which induced me to join Mr. Cruickshank. I have already received the greatest justice from the Admiralty, who have been so kind as to give me permission to coat a portion of one of their ships.

Mr. BEALE: Does Captain Warren take any measure for riveting the surface, or does he put the glue on the surface of the metal? I understood from Mr. Gisborne that his composition will last for twelve months. I do not know how long Captain Warren says his patent will stand, how long the copper will remain firmly attached to the iron, and in how many years it will be affected. Captain Warren spoke of the length of the commissions, but he did not state any definite period.

Rear-Admiral Sir EDWARD BELCHER, C.B.: For a great number of years my attention has been directed to the fouling of copper on vessels by crustaceæ. I found, particularly at Bermuda, where we were stationed for two years, that the *animalculæ* preferred the oxide of copper, which is poisonous, to any other substance on which they would fasten. I grew corals on my own account. I began with Lady Lumley's scent bottle, and I grew a coral tree on it for her. I tried jars, bottles, iron, the back of a knife, the sole of a shoe, a slate, and every possible substance that I could get hold of, and I had a beautiful museum of these things. The controller wrote to me the other day, asking my opinion whether coralline would attach themselves to glass in preference to any other substance, and whether the coralline so attached would be more difficult to remove. I remarked distinctly, the corallines were more difficult to be removed from vitreous surfaces, and could not be removed by an ordinary scraper; but wherever they came into contact with copper, which is slightly oxidised, they scaled off immediately, because they came off with the oxidised portion. In 1824 Sir Humphrey Davy commenced his experiments, by adding zinc plates on either side of the stem, to endeavour, by galvanic action, to overcome oxidation. I do not know if chemists understand exactly why the animalculæ decline to attach themselves to copper which is so protected; but if they will place a zinc plate under the tongue, and a silver plate over the tongue, and bring the two in contact, they would find that the insect would experience a tingling, sharp sensation, which would warn him off the copper. As long as the protection was in proper proportion, and the galvanic action kept up on the surface of the copper, to the destruction of the more oxidizable metal, zinc, so long we had no insects settling on the outside of the copper. The zinc was covered with weeds and coralline, but the copper, so far as I witnessed the experiment, was perfectly free from anything of the sort. In 1824 we were treated in a different manner. We had under each fore-chain an iron plate, nine feet long, and above four inches wide; and a similar one under the mizen-chain on each side. The ship was four years and a-half in commission. Her copper was constantly bright and clean; but when we came home to England, weeds and *animalculæ* were found attached to those four spots. When the "Blossom" was docked she was perfectly clear, except where the iron was; but the iron was gone, for as we were going into dock the iron tumbled off in a lump, in a state of oxide. In 1830 Captain Sweeney took out a patent with some Frenchman for protecting ships' bottoms sheathed with polished iron. He had a brig, and she was protected by this method, by zinc bars. Tanks were also fitted up at Portsmouth, and water was kept in the polished tanks

for four or five years without any alteration taking place in these tanks. The brig which went out to Halifax was found very foul; the plan did not answer at all; but it did answer internally in the tank.

The CHAIRMAN: Were those tanks made of iron or zinc?

Sir EDWARD BELCHER: Iron, with zinc bars. At the time I fitted out, in 1831, the Government provided me with zinc bars for the purpose of following up these experiments. I found, where the connection took place between the iron and copper, at the stem of the boat, that the zinc interposed there did protect the iron from corrosion. To show how rapidly barnacles will form, I will mention an instance that came under my own experience. In 1830, when my ship was in dock, I had an idea that if I whitewashed it I should keep off a great part of the galvanic action between the heads of the nails and the copper; and I thought that when the ship got to sea she would wash off all the river scum and be clean. We sailed in December, and we returned in the August of next year, only seven months away. At the Navy Office, in the collection made by Sir William Symonds, you will find barnacles four and a-half inches long taken off the vessel, and which were named after me. They were found in plates along the whole line of the keel, where the lead came in conjunction with the copper. That circumstance shows how rapidly barnacles will form on copper. I am afraid this composition of Captain Warren will not stand the wear and tear, unless it is very heavy copper. Is that 32-ounce copper?

Captain WARREN: The 28.

Sir EDWARD BELCHER: When it comes in contact with a rock, or with any other rubbing substance, I question whether the difficulty will not be greater than if the end were not simply pointed. I believe a patent will be taken out at the end of this week for the protection of the walls of the Houses of Parliament. The inventor of the secret has a peculiar varnish, which has been applied to iron that has been for four years under water; it may be seen at the Kensington Museum. The varnish which was under water the whole time was less affected than the varnish which was exposed above water. It was applied under Sir Baldwin Walker's directions, and was forgotten for a time.

The CHAIRMAN: Do you know the price of that varnish?

Sir EDWARD BELCHER: It will be very cheap indeed; but until it is patented no one will know anything about it. But I can tell you what the groundwork of it is. Nero was buried in his vessel, which was covered with this same pigment. It has no moisture in it at all; and it will not yield moisture under distillation at red heat. The varnish in question has puzzled Professor Faraday. He states that, so far as he knows, it will do everything that the patentee states it will do. When Nero's vessel was got out, a portion of it was placed in the Museum at Rome; and Cardinal Mezzofanti allowed this man to buy some portion, and with that he bought his secret, for he examined the paint and discovered what it was made of. I have seen two letters, one from Glasgow and another from Liverpool, asking for further supplies of the paint, stating also "it is the best covering for bottoms they have had as yet."

Mr. LEETCH: I have heard with a great deal of pleasure the arguments this evening. I think the subject is one of sufficient importance to call for a few observations. The first thing is to preserve iron from corrosion; the next thing is to prevent the adhesion of the animalculæ to it. All the attempts to use copper on iron vessels have hitherto been failures, because the galvanic action which will result from damage to a portion of the copper, will cause the galvanic current to go right through. It at first sight seems a ridiculous idea to think of glass, because, being so brittle, it is believed that it will break. So long as it is afloat, it will not break; but, if it goes on a rock, of course it will. But there is the fact that nothing will permanently adhere to it. Many people imagine that things will adhere to it. So they will; but they will never be able to eat into the smooth surface, and, therefore, never be able to cling to it permanently; they would be wiped off as easily as the incrustation off a bottle in a cellar, or as dust off a window.

The CHAIRMAN: Perhaps you can tell us the result of your experiment on the "Buffalo."

Mr. LEETCH: The result has been completely successful. I exhibit a piece of the glass sheathing that was twelve months on; there is nothing more on it now than there was at first. I should not think of putting glass on so thick as that, nor would I think of doing it in the way it was done, for it was done in a hurry. The great object is to preserve the iron. Iron, at present, is not being treated in the way it ought to be treated for sea-going vessels. My own impression is, that if the iron was left with its own natural skin, it would be much better than with any of the applications that have been put upon it up to the present time.

Mr. MOYSEY: I have listened with great pleasure to Captain Warren's paper. With regard to one remark that he made upon the friction of water on iron my experience is very different. I left Plymouth Sound in 1853 on a cruise. We went to Lisbon and Madeira, and different places; but before we left, being an engineer on board the ship, I put a piece of tallow on the driving side of the screw. We came back from Lisbon, after steaming some thousands of miles. We then steamed up the Baltic. By-and-bye we lifted our screw for examination, and, to my astonishment, this piece of tallow was still on the driving side of the screw. There was a remark made by Captain Warren which, as Mr. Peacock is not present, I wish to correct. He said that Peacock's composition contained copper.

Captain WARREN: I beg your pardon.

Mr. MOYSEY: That is not the case, for it contains no copper, and is perfectly harmless. Mr. Gisborne spoke about the cost of his composition. If the "Valiant" has on one side 8½ cwt., how is it that the "Kingston" of 700 tons takes 10 cwt.? and to that has to be added the cost of docking and preparing the vessel. As to the "Kingston," I do not know whether Mr. Gisborne intends his composition to dry; if so, why was she kept in dock so long after it was put on? And this morning, at seven o'clock, the composition was just as wet as when it was put on.

The CHAIRMAN: Where is she docked?

Mr. MOYSEY: At Fletcher's dry dock. I should also like to hear what was the Admiralty Report of Mr. Gisborne's composition on the trials that have been made.

Dr. COLLIS BROWN: May I make one remark with reference to the preparation of Mr. Gisborne? It is stated that it consists of mercury, and other combinations, with lead and oily substances; that the destruction of the *animalculæ* and marine *algæ*, takes place from galvanic action. I rather attribute that to other changes. He has forgotten that where oil comes in contact with the galvanic current, the galvanic action ceases. There is nothing so destructive of galvanic action as oil. One proof I will give you is the steam-boiler, where an electric current is given off a steam-boiler it is corrected by a few drops of oil. The anti-fouling poisons that result from the use of mercury, I should rather attribute to the calomel that is formed. The fatty substance that is produced destroys galvanic action.

Captain SELWYN, R.N.: I wish to draw Captain Warren's attention first to a point which I do not think he brought out with sufficient importance—that of the rivets passing through the felt, in some instances, and touching the iron underneath. That would be sure to produce an accumulation of electric action, due to the two metals coming in contact at those points. There would be a strong local action set up. Secondly, to the fact, that wherever you put copper and iron together in a vessel, exposed not alone to the water of the sea, but even to the moisture of the atmosphere, there you will inevitably have a strong galvanic action. There is no known means of stopping that. Probably, if you could keep a band of grease at the junction, that would be more efficient than wood or anything else. There is no part at which there is not a deposit of salt water upon it, and that salt water is the conductor to continue galvanic action through. I think it would be cheaper to build our ships of copper than to go into plans for making copper bottoms to iron ships. If we are in that way to accomplish the object in view, it clearly must be by abandoning iron bottoms of ships altogether, and having the whole outside of the ship of wood. If you can do that, and having done that, if you can keep the ship from straining, opening her bow ends, and letting in the water to the inside iron, then you might succeed; but short of that, I am sure the galvanic action will go on. With regard to the black fluid of which Captain Warren spoke, as oozing from behind the plates of the "Royal Oak," it is nothing but the gallic acid acting upon the iron, and producing

tanno-gallate of iron as a result of an electric current between the copper and the iron, the iron forming the more destructible metal in the couple. We have there, in the iron, the oak, the gallic acid, an action going on which has this result, that the iron becomes the positive metal; the copper is protected from that oxidation which is the only means of preventing the deposit of all substances on the bottom of a ship. So sure as you prevent exfoliation, whether that exfoliation is produced by the destruction of the copper, or the destruction of any other substance that you choose to put there, so sure are you to have a deposition of barnacles, grass, sea-weed, and other materials. Here is a bottle which the Secretary has been kind enough to bring for your inspection. I was aware that in the Museum and elsewhere there were a great number of bottles that had been recovered from the sea at various times, and which have been covered with barnacles. Sir Edward Belcher has seen not only submerged bottles, but bottles which floated about the ocean perfectly covered with barnacles and sea-weeds. I may mention a curious fact to show the way in which Nature obviates this deposition of *animalculæ* when one of her operations is stopped. In the North Pacific we came across a large old whale, which had become diseased, and which was so covered with barnacles and shell-fish from head to tail, that we really took it for a half-tide rock, and we lowered our boats to examine it. The only way we could account for it was, that the fish was diseased, and that it had ceased to secrete the *mucus* which all fish secrete in health, and which protects them from the deposition of barnacles.

Sir Edward Belcher: All whales have barnacles.

Captain Selwyn: There is the barnacle proper to the whale, just as there is the louse proper to the salmon, but that is not the kind of barnacle that we saw. The practice of coppering vessels is now going out. As regards the wooden and copper vessels of which Sir Edward Belcher spoke, there is no possible doubt that if you sacrifice any one metal in a couple, you may protect the other. I had a wooden vessel on the coast of Africa, whose iron rudder was in a state like red cheese, from galvanic action; and as for stopping that by the application of felt, where you have copper nails passing through it and the points touching the iron, you could not do it. Mr. Gisborne has brought before us a composition in which mercury plays a part. I am sure he is too good an electrician not to see that there are no two metals in contact in salt water, in which a galvanic action does not go on. I attribute the success of his composition more to the fact that his paint is so made that it gradually wears off, than to the fact of its having any mercury at all in the composition. I think the probability is that with copper you get a more energetic action, but with mercury, you will get some, in any of its forms. The object of all compositions, hitherto, has been to protect ships' bottoms, not alone from oxidation, not alone from fouling, but to do both at the same time; and I do not think, unless we get some application of the mineral oils that have been spoken of in this theatre, that we shall be successful. The plan of allowing the oil to flow out of the ship's bottom has this to recommend it—that wherever grease or oil from a ship's bottom is allowed to come out from the bilge pumps, there you find, in the immediate vicinity, and in a line upwards to the surface of the water, an entire freedom of attachment of any description. Some will say it is due to the frictional action of the water. I confess I think it is more due to the oil that is oozing out, being carried against the ship's bottom, and greasing the surface in its passage upwards. I see no possible reason why, if the oil be emitted at the bottom of the ship, you should not produce that action over the whole surface, that you have produced over a small portion of the surface. I take the greatest interest in the subject, and I have my best thanks to give to Captain Warren and Mr Gisborne for bringing forward the subject, for as I said in a former paper, the whole secret of success in naval warfare *must* depend upon *speed* and the power of *keeping up that speed for the greatest amount of time.*

Mr. Leetch: Speaking of oils, you all know that fatty matter will evaporate after a certain time and will become dry. With regard to glass, if a bottle is sunk to a number of fathoms in the sea, and is allowed to remain there, things will accumulate upon it; but where a vessel is kept moving about in the sea, there is very little chance of anything adhering to it. But barnacles will not adhere permanently to glass placed on ships' bottoms. The only instance I know of is that in the case of a

bottle obtained from the wreck of the "Royal George;" there, one incrustation had actually eaten into the glass, it having been sunk nearly a hundred years.

Captain WARREN: I am very sorry that Mr. Hay should have been so distressed. I really thought, in what he said on the occasion in question, that it was a little piece of sarcasm on his part, and you see it by the context:—"I think the subject should be taken up by chemists who should work at it for twenty or five and twenty years."

Mr. HAY: "Who have worked at it for twenty or five and twenty years?"

Captain WARREN: I quote from the volume of the *Transactions of Naval Architects* referred to by me. Mr. Hay is made to say, "I think the subject should be taken up by chemists who should work at it for twenty or five and twenty years," and as the context shows, Mr. Hay could get no reply to his scientific questions I do not think he gave himself a very long period to settle the question. Mr. Hay, as the Admiralty chemist, tells us that wood is a very perfect conductor between two metals, Mr. Reed, the Chief Constructor, says that it is the only effectual interposition, so thinks differently, but I do not see how that can affect Mr. Hay in any way as a scientific chemist, which Mr. Reed certainly is not. As far as the "Recruit" is concerned, I quoted the "Recruit" as I quoted other vessels; I quoted the case of the "Megæra," which was a much worse case than that of the "Recruit," and in which Mr. McInnes and Mr. Hay's compositions were used on different sides, and she was described as a putrid mussel-bed. There was one portion which I had noted, but which appeared to me so strongly worded, that I did not intend to read it. I will read it now, it is from the naval intelligence of the "Times":—

"The 'Warrior,' 40, iron frigate, Captain Arthur A. Cochrane, C.B., in the dock at Portsmouth, has, according to established custom, had her hull, below the water-line, and the compositions and experimental sheathings with which it is coated, examined and reported upon to the Admiralty by the officials of the dockyard. It is four and a half months since the 'Warrior' was in dock. She was then coated below the water-line with the preservative and anti-fouling compositions prepared by the Admiralty's Chemical Assistant, and at the same time had three patches of 'Brown's vitreous sheathing' attached to her port side. The ship's bottom, as she now lies in dock, has the appearance of a well-made thrummed-mat, being covered with a fine crop of tuft weed, which must have grown at the rate of about three-quarters of an inch per month since the ship has been afloat, to reach its present condition. The vitreous sheathing had less of this weed upon it than the compositions, and they have adhered to the ship's bottom with two exceptions."

Mr. HAY: May I be allowed to make one observation upon that? With respect to that last quotation which Captain Warren has been so polite as to introduce, that has been publicly denied in the newspaper; and I assure you that Captain Warren, who is in the habit of seeing ships, might have brought forward some that had come under his notice personally, rather than have taken up loose newspaper reports. There is one vessel that has been seventeen months coated since last docked—she has been coated for seventeen years on my plan and the iron and rivets are as good as when put together. Captain Warren knows this, as at the time of the examination of the mortar-float, sheathed on his plan, she was in the same dock.

The CHAIRMAN: The simple fact is, Captain Warren has read an extract from a newspaper, and you state that it is not correct.

Mr. HAY: Certainly so. I wished to make a few observations upon the subject, to confute the arguments that have been brought forward, followed by these beautiful illustrations.

Sir EDWARD BELCHER: If the accounts that we read in the newspapers were to be taken as facts, the Admiralty would be very much to blame for employing Mr. Hay any longer. But, if the Admiralty are satisfied, I think we ought to be.

Mr. GISBORNE: In reply to the remarks upon my paper I will not detain you more than one or two minutes. 1st. In reply to Mr. Halkett, we tried corrosive sublimate and other preparations of mercury, and found them to be exceedingly deleterious to the efficacy of the paint. 2ndly. Dr. Brown remarked that there could be no electric action upon mollusks that attached themselves to the paint on

account of the oil in it. But, when paint is completely filled with minute particles of quicksilver, so soon as a mollusk fastens upon it the fish feeds upon the skin of oil until, by uncovering a globule of mercury, galvanic action acts upon it. Captain Selwyn mentioned that no metals come in contact with salt water without galvanic action arising; the mercury I use would not however adhere to iron but for the oil which insulates it from the iron, as already explained in my remarks upon adhesion. One of the patentees I have named, employs mercury with grease to prevent galvanic action upon one side of the zincs in a battery. You have heard that red lead is a very good anti-corrosive; yet, when brought into competition with my paint, as on the plate now before you, you will notice that two coatings of the best red lead have not prevented destructive corrosion, while my side is perfectly clean and free from all corrosion, and what is remarkable, as you will perceive upon closer inspection, is that even the hammer marks made in flattening the plate and which scaled the iron show through the paint without any corrosion upon their abraded edges. This plate has been submerged six months and is authenticated by Lloyd's agent at Milford Haven. In reply to Mr. Moysey I beg to state that we did not paint the "Resistance," the "Valiant" being the only one of Her Majesty's ships under experiment. She went into dock on the 12th, and had three coatings, each coating drying within twenty-four hours, and in reference to the merchantman, "Kingston," I ascertained upon my return to town, after a fortnight's absence, that good *boiled* linseed oil had not been used with my paint, and the paint will not dry quickly unless such oil is used. If you paint two plates of iron with my paint and allow it to set an hour or two and then submerge one plate, the plate so submerged will dry more quickly than the one left in the air. The best proof, however, of all paints is to test them by actual experiment at sea.

Captain Warren: Captain Selwyn made a remark as to the rivets. The felt which was tried before was a very thin felt. The felt now is so thick that if the rivets were driven in in the form of nails, they would not penetrate through it to the iron. Mr. Beale asked a question as to the length of a ship's commission. A commission is usually for three years, so we believe this copper will last six years. I now think that I have answered all the questions put to me. I knew very well before I came here that composition-makers and African travellers are the most belligerent of people.

The Chairman: I will not detain you long by making any observations myself. I think the conclusions to which we must all come are:—first, that it is a subject of the very greatest importance; secondly, that it is not at all an easy problem to solve how to coat the bottoms of iron ships. I think the fact of the very large number of patents, and the innumerable substances which have been tried on various occasions, are sufficient proofs that the subject is not easily handled. I believe I may say that we have not, as yet, hit upon the right method of preserving iron ships' bottoms. I think it is a matter of regret that Captain Warren has not been able to tell us that his sheathing has been tried at sea. It is quite possible that his plan may be so far good as to preserve an iron mortar-boat while in harbour; but so far as I understand him, it has not been tried at sea.

Captain Warren: It has not.

The Chairman: Therefore, I quite agree with what Mr. Gisborne said just now, that the only way to prove these compositions is to try them at sea. I have a recollection of having occasionally been taken to a ship in dock, and I have been told to look at one side and then at the other; and I could really see very little difference. On one side was Mr. Hay's composition, and on the other was what we called the Woolwich composition, which is simply coal-tar and a little spirits; and I could see no difference. With respect to the new patent which Sir Edward Belcher mentioned for preserving the stone-work of the Houses of Parliament, so far as I have heard, it is a vitreous composition.

Sir Edward Belcher: No. I cannot inform you of the secret.

The Chairman: My impression was, that being a vitreous composition, all the objections which Sir Edward Belcher applied to Mr. Leetch's plating of glass would apply to this vitreous composition. However, I shall not detain the meeting by going into a variety of points, especially with reference to the coppering of iron-cased

ships. The matter has been very much considered, and I do not know how the question stands at present. I think the "Royal Sovereign" was covered with peculiar corrugated plates.

A MEMBER: They have been removed.

The CHAIRMAN: I do not know the present state of the "Caledonia." A belt of wood was originally placed between the Muntz's metal on her bottom and her iron plates; it was well-known that damp wood is a partial conductor, still it was supposed that this would be a better plan than bringing the Muntz's metal right under, and in contact with, the armour-plates. If that had been done, there is no doubt that the armour-plates would have been ruined. I have now only to thank Captain Warren and Mr. Gisborne for preparing these papers and bringing them before us.

LECTURE.

Friday, April 7th, 1865.

Field-Marshal H.R.H. The DUKE OF CAMBRIDGE, K.G., &c., Commanding-in-Chief, Vice-Patron of the Institution, in the Chair.

SHERMAN'S CAMPAIGN IN GEORGIA.

By Captain C. C. Chesney, R.E., Professor of Military Art and History, Royal Staff College, Sandhurst.

Your Royal Highness, Ladies and Gentlemen,—If it needed any apology that I should appear a second time within two years to lecture in this room upon the same subject, I would make it by appealing to you to recall the different phases of interest which the view of the American war has assumed throughout our own nation, and, I may say, throughout nearly all the civilized nations of the earth.

When I last lectured upon the subject here, the American war was, so to speak, in a military point of view, at a discount. The first interest of the outbreak of the struggle had altogether passed away. There was at one time—when we saw a man who a few days before had been a country lawyer, ordering out hundreds of thousands of men to crush a rebellion which counted itself ten million strong—there was naturally an amazing deal of interest in this country, for political and other reasons, to watch what the result of the struggle would be, which men generally thought would so soon end. When, following upon that, we read from one of the most brilliant pens of our own time of the fatal battle of Bull's Run, and the disgraceful rout that followed that battle; and when we heard of the ridiculous mistakes that were made by the American Generals at the beginning of the war, such as the notorious errors which I spoke of formerly of General Pope; then naturally the mind revolted from following the whole details of the proceedings. The American war was looked upon generally by people in this county—even by military men—as a sort of chaos of butchery, a series of indecisive battles, of which nothing could ever come, and by which the struggle in the end must wear itself

out. And as to deriving any lessons or learning anything from it, military men here were of opinion (and the same remark was made by officers of rank in India, and also in Paris) that it was impossible to learn anything from these operations.

I first applied myself in this Lecture-room to shew that this was not strictly the case; that there were certain great principles in war, simple to put into words, simple to understand, from which at no time (save in exceptional cases) could generals deviate without meeting evil consequences. I think I proved clearly what I laid down from certain examples drawn from the American war, viz., that allowing for the differences of the war, allowing for the difference of the peculiar troops employed, and the difference of the communications which the Generals worked upon, their principles were, *or ought to have been*, the same which have animated Cæsar, Hannibal, and Napoleon. But then I should have gone further; I should have said that although little men like Pope and Hooker cannot deviate from those principles and go in the face of them without suffering very severely for it, there are times when men of genius in war, as in almost every other art, rise and take their flight above all rule, and, as it were, lay down principles for themselves, knowing where the impossible begins, and what is only difficult, and how that difficulty is to be got over.

In the campaign of General Sherman in the last autumn we have striking illustrations of the value of military principles thoroughly worked, and also of the impunity with which soldiers of genius can lay aside those principles. It is this campaign which I propose to bring before your attention to-day.

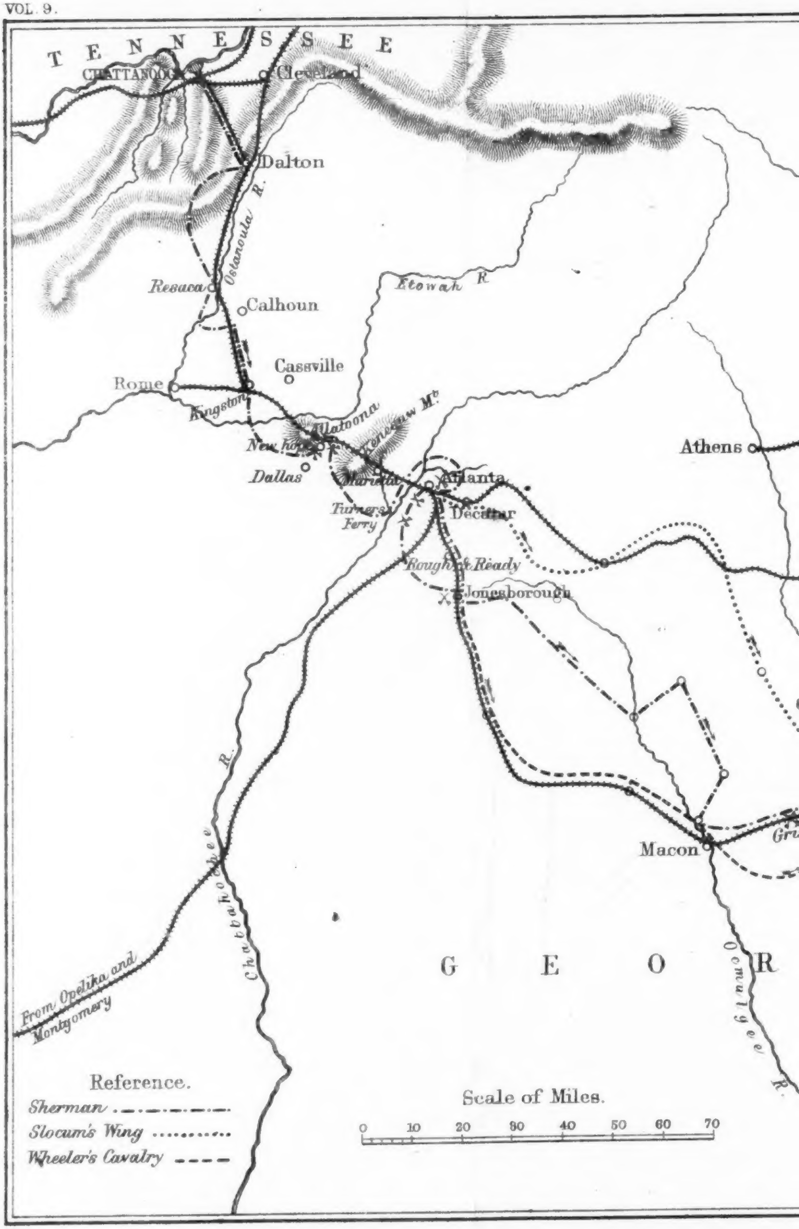
There is, however (I would add as a preliminary remark), a plain lesson as to modesty, in our judgments of such matters, to be drawn from the subject of the American war; and this lesson most of us have now well learnt. When we all read Dr. Russell's brilliant account of Bull's Run, and of the rout which followed that battle, the conclusion was immediately drawn that because the Federal soldiers ran away, and the Federal artillerymen tried to cut the horses out of the waggons and leave their guns behind in order to escape, and men were ready to fire at their own officers or anybody that attempted to stop them—the conclusion, I say, was immediately drawn that the Federals would never fight, and that their generals could never lead them to victory. Now the wise people who drew that conclusion forgot that in their own fathers' time, when France was throwing her men under arms by the million, as America is doing now—when she hurled her armies on every frontier in order to save herself from being crushed by her numerous foes, the very same events occurred which Dr. Russell has pictured as happening at Bull's Run in 1861. There were the same sudden panics spreading from 100 to 1,000 men and then to 10,000; the very same flight through daylight and through dark, the same unpleasant tendency of the runaways to fire at their own officers. All these things happened as distinctly, and are as plainly recorded, in the history of the war of 1792-3 as that of the war of 1861.

It was nothing new, neither should it have been held strange, that

men fight ill when badly led, when we consider that in the memory of many men now living the Prussians, when first attacked by Napoleon in 1806, laid down their arms by tens of thousands, and dispersed like sheep. Yet nine years afterwards those very same Prussians were welcomed by us as they pressed to our succour at Waterloo. Notwithstanding these examples, the critics of this country came to the conclusion, after so disgraceful a rout, that no Federal generals or soldiers could be found to fight, forgetting that these Federal generals, though men of little experience in war, *were of a great deal of experience in training.*

Let us take the instance of General Sherman. I do not pretend to say that he is a second Cromwell. I do not know whether he is aiming at any extraordinary empire to be raised out of the South, but I do think he is a man of extraordinary abilities. We all know now that he is a remarkable man in the true sense of the phrase; and most of the information that was given to the world this week in a letter to the "Times," from Richmond, has been familiar to me for some time. He is indubitably an eccentric man; talkative at times, silent at others; reserved to his men generally, and occasionally very familiar. That he is decidedly a thoughtful man has always been his reputation. He has a touch of the professor in his method of war: for, like Stonewall Jackson, he had long been a professor in one of the military academies. Withal he is a man of original genius; for he is the first man in this war who saw long ago that it was perfectly possible to conduct a campaign without keeping his army constantly within a day's march of a railroad, or a river covered with steamboats. Some of you will remember—I am sure many of you will—that at the beginning of the American war the Prince de Joinville, who was present himself at the commencement of the campaign, laid it down as a principle from which American generals could not deviate, that they must keep their armies within a day's march of the railway, or of the line of steamboats, which should bring them their supplies. Sherman was the first man to shew that if he got a country tolerably fertile, stripped of male defenders and abandoned to women and slaves, and supposing that in that country the people should have been induced beforehand to grow very large supplies of corn and everything of that kind, with the idea of feeding their own armies, he might take his army through that country, and feed his men with the food grown for their enemies. Upon that principle he founded part of his campaign of which I am about to speak. But I here would point out that the thing had been devised many months before, and that he now put into practice the mode tried so long ago as the February and March of the previous spring (1863), for the purpose of seeing whether the thing was practicable, and that he used it in consequence of seeing that it was practicable.

There are two plain lessons taught by this campaign, which I hope our brief study of it to-day may illustrate. First, the importance in war of threatening your enemy's communications, whilst securing your own. Second, the possibility in such a case as that already indicated of taking an army across country without any regular line


TENNESSEE
CHATTANOOGA
Cleveland
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Kenesaw Mt.
New hope
Dallas
Marietta
Atlanta
Turners Ferry
Decatur
Rough & Ready
Jonesborough
Athens
Macon
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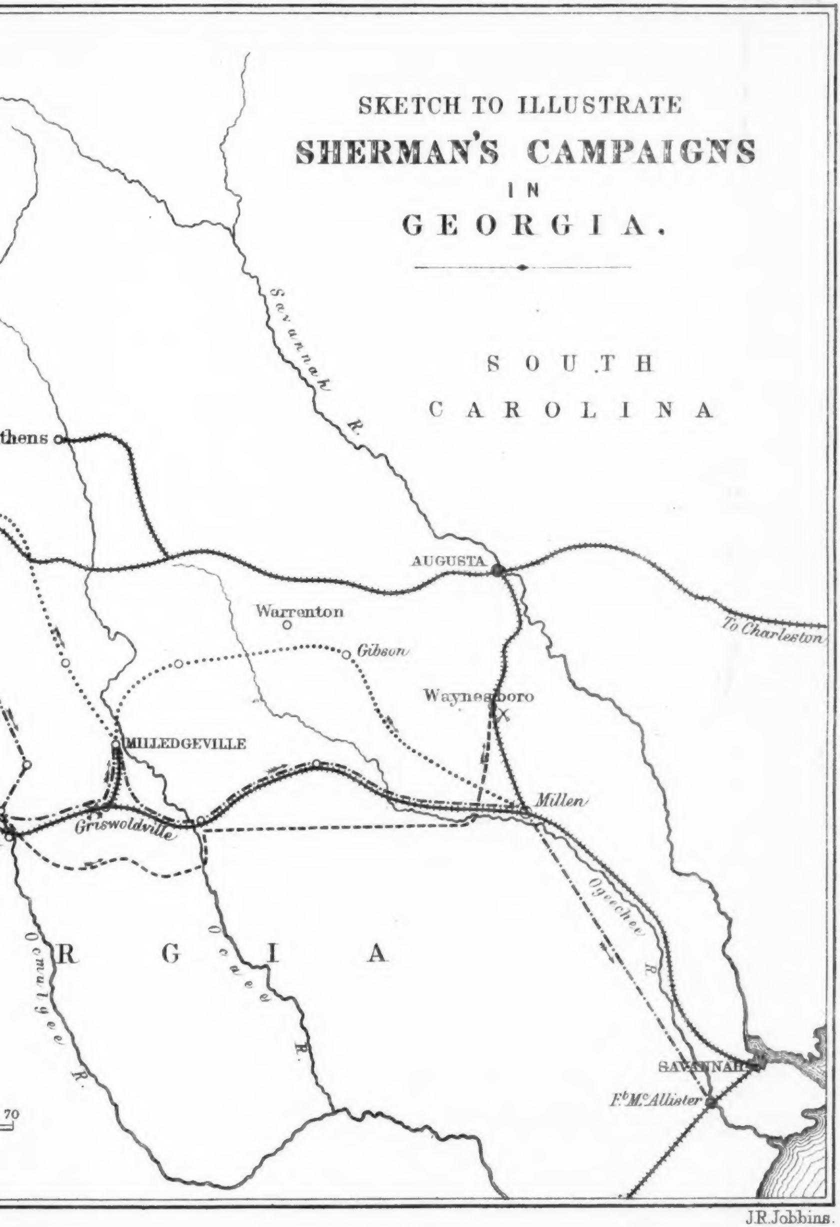
SKETCH TO ILLUSTRATE
SHERMAN'S CAMPAIGNS
IN
GEORGIA.
SOUTH
CAROLINA
Savannah R.
thens
AUGUSTA
To Charleston
Warrenton
Gibson
Waynesboro
MILLEDGEVILLE
Millen
Griswoldville
Ogeechee R.
Ocmulgee R.
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R G I A
SAVANNAH
Ft McAllister
70

J.R.Jobbins.

of communications at all. The practice of the first brought Sherman into Atlanta; the other gave him Savannah.

I now proceed to my story. I ask you to look for a moment at this large map, and particularly at the city of Nashville, the capital of the State of Tennessee, which was the head-quarters of the Federals more than a year ago. Here is the State of Tennessee, divided nearly, but not exactly, by the river of the same name from the other States to the south of it. Chattanooga, the celebrated crossing passage of the Tennessee, had long been held by the Federals. In March of last year General Sherman was appointed to the command of the whole of the armies stationed in and about the State of Tennessee. He succeeded his own friend and former superior Grant, who was now elevated to the chief command of the whole United States' armies, and at whose meeting at Nashville (which in after days will be a very historical one) with Sherman, for the purpose of arranging that series of campaigns which terminated last year, the joint plan was settled. The plan was simple enough. Grant was prepared to stake his own reputation (which was then already very great), and the lives of a great many men, against the celebrated chief who had so long defended Richmond, General Lee. It was expected of him by the nation who had made him Commander-in-Chief that he should attempt the capture of Richmond, which he attempted, and in which he throughout that year failed. But he left behind him the whole of the armies that he had previously commanded in charge of General Sherman.

The design agreed upon between the two Generals was, that Sherman, starting from Chattanooga, on the River Tennessee, to which point he had the advantage of railroads and a navigable river, should work his way into the heart of the great State of Georgia up to Atlanta—called, from its commanding position, the Gate City—from whence he might take his own further course as best he might think fit, if he only once got there.

To reach it was the first endeavour he was to make, and he proceeded forthwith to concentrate the various armies placed under his command. They were three in number. From his own report they numbered almost as exactly as possible 100,000 fighting men. They were divided very unequally. The army which he had previously commanded was 25,000 men. This was placed under the command of Macpherson, a young man of very rising reputation, who fell in the campaign. There was a second army of 60,000 men, which had been previously in Chattanooga, under the command of General Thomas. There was also a third army of 15,000 men from Kentucky, under General Schofield, the same who has been recently moving in North Carolina to join Sherman from the coast side. These three were collected together and brought to Sherman's hand at Chattanooga. He made no change in the organization, for he did not think it necessary to break them up and form them into one army. He fought his whole campaign on the principle of letting these different generals command the different armies before placed under them. Perhaps his reason for this was political; however, he had good reasons doubtless for it.

In the early part of May he placed his troops ready for service. A

few miles only beyond Chattanooga had been penetrated by the Federals. They had got nearly as far as a little place called Dalton, which is about 20 miles in a straight line from Chattanooga. Throughout his advance, which was a very lengthened one, his own previous army, now under Macpherson, was held to the westward or right, and Thomas's, the largest army of the three, was placed in the centre. Schofield's, the smallest, was placed to the left, or east. In that order they came down to the extremities of the lines they held, and faced the Confederates, 100,000 strong. The Confederate General who had to oppose them was very much weaker in men certainly. His army, deducting the cavalry of each side, numbered just one-half of Sherman's army. He was, however, rather stronger in cavalry than the Federals. He had altogether about 54,000 men to oppose the Federal 100,000, and even all these had not come up. In the beginning of May, when the Federal advance was made, some of his troops that had been detached 200 miles to the west, under General Polk, for another purpose, had not yet joined. He had, therefore, only about 40,000 men at the commencement of the campaign. His problem was simply to stop Sherman as long as possible. He had scarcely a hope of beating him decisively. There was no hope now for the Confederates of concentrating suddenly a superior force on that same line as they did in the year before, and then advancing on the Federals to crush them, as, under Bragg, they had done at Chickamauga. The time for that was gone by; but with an inferior army, General Johnston, a man of the highest repute when the war broke out, had, as I have said, the task of detaining Sherman as long as possible. We shall see how he performed that task. His headquarters were at Dalton. In front of Dalton there is a steep hill, which made the position so formidable that Sherman, a cautious general, did not choose to attack it. He had to devise in the course of this campaign a plan by which he should turn, not one such hilly position, but half a dozen at least successively; and thus, without wasting his men in vain attacks upon Confederate entrenchments, force his foes to fall back along the railroad from Atlanta, which they so much wished to cover.

The plan in words was simple enough, but difficult in execution. It was just this. Having an army superior in numbers, half of it would cover the front of the Confederates. He would then be able to detach one half at a time in whatever direction he chose. If then he could keep the Confederates pinned to one place by watching them with part of his army, the rest might move round, and come upon the railroad behind them, and so force them to retreat. To do this required a great many waggons; for that part of the army which moved had to keep itself for several days in a mountainous district stripped of supplies. It required a good general to be sent away on so detached a service, almost into the rear of the enemy; and it required many other conditions (which men of genius like Sherman understand better than ordinary mortals) before he could overcome such great practical difficulties. That was the general idea of the plan, and he at once, when his commissariat was ready, began to

carry it out. Having on the 6th of May arrived before his enemy and felt his position, and found it exceedingly strong, and being determined to save his men as much as possible, he commenced his flanking operations. It is about 15 miles from Dalton to Resaca, in Johnston's rear. With a sweeping march Macpherson was sent away (furnished with a supply of waggons to maintain himself for a few days without communication) to come down upon Resaca, and threaten the rear of the Confederates. But the point he approached had been entrenched by them, and when Macpherson drew close to it he thought himself not strong enough to force his way into the rear of the enemy with 25,000 men, and attack the entrenchments along the railroad.

Entrenchments formed a very important part of this campaign, and it is necessary to state of what sort they were. You have doubtless seen a paper lately appearing in one of our chief Quarterly Reviews, which describes what the entrenchments used recently by Grant and Lee, consisted of. It states properly that they were fighting mostly in the midst of woods. That was not the case here. A great part of the State of Georgia has been cleared, and the cultivation is on a very large scale. It was so before the war began, and it was so at this time. The object being to prevent the wandering of the stock, and to save labour especially, and wood being amazingly cheap, it is covered, as I am told, where the troops have not removed them, with rough, but very heavy rail fences. Early in this war the men were trained to throw down these fences, to break them into pieces, and form them into a heap of about two feet or two and a half high, behind which the men might crouch and safely avoid bullets. Then a little earth was thrown up, some trees cut down, and a breastwork made, sufficiently strong to keep them from ordinary artillery and musketry fire. These were the original entrenchments. Then ditches and rifle pits were often formed, and in a short time a strong position made. This was repeated hundreds of times in the course of these Western campaigns.

So when Macpherson tried to force his way into the rear of the enemy and get on to the line, he found the line entrenched and held by, to him, an indefinite number of men, and he did not choose to risk an attack. Sherman's scheme seemed to fail, but his plan of getting over the difficulty was a simple one. He strengthened his own position in front of Dalton, and sent reinforcements to General Macpherson under General Palmer and General Hooker (the notorious failure of the year before) until 50,000 or 60,000 men were assembled opposite Resaca. While this went on, it was discovered by the enemy, who thought it was time to move. On the night of the 10th of May Johnson broke up his first camp at Dalton and retreated to Resaca, having at this time (as before intimated) about 40,000 men under his command. He prepared to entrench himself there, evidently expecting to be attacked. But not so; Sherman, determined to make another move with his right, struck into the road which crossed the river Ostauoula (the rivers here are known by their Indian names), moving once more by his right, and threatened the passage of the river below so as to cross and come upon the Confederate rear there. Five days he took

to move Johnston from his first position. In five days more Johnston was forced in the same way to move from his second. The latter fell back, as he says himself in his own report, easily at this time, because the whole of his army was not up, and because he understood also that the Federals were leaving large depôts behind, and were otherwise diminishing their armies; so that he thought he might fight them afterwards to greater advantage. He retired southwards till he got to a more open piece of country before the little place called Kingston, from which there is a branch to a place of some importance named Rome. Retreating in that direction, Johnston met the last division of his army under Polk. He knew he could expect no further reinforcements, and he turned and took up a strong position, intending to fight a general action on ground which he had not yet entrenched in front of Cassville. The enemy came near him. I cannot pretend to enter into the particulars of the dispute which followed, but I should explain that his army was commanded by three generals. One corps was commanded by Hardee, an officer apparently on good terms with him, the other two by Hood (who succeeded him), and by Polk, the well-known episcopal general, who saw the war begin as a bishop and died in it as a soldier. It is clear from Johnston's own account that he was not on good terms with either Hood or Polk, and when he drew up his troops on the 19th of May for the encounter, these two generals objected to the position in which they were placed. It is evident there was considerable independence of action in his command, and the objections had so much weight that, notwithstanding his opinion was supported by the third, General Hardee, he broke up his position and retired, determined to continue the course of entrenching and not trust his army to a general action. That same army had been beaten severely in the autumn of the year before by General Grant, on the heights just in front of Chattanooga; therefore, there were very good reasons for not risking a decisive battle. They had then received a most tremendous and decisive defeat, and been driven out of their entrenchments with very serious loss—a loss which they never recovered.

So the Confederates retired and crossed the stream Etowa, the next principal river on the line to Atlanta. They abandoned the other side of it to the Federals, who instantly seized the junction at Kingston and Rome, and entrenched them both, making depôts of them. Then began the grand difficulty of the campaign. Between the River Etowa and the River Chattahoochee, which covers the town of Atlanta, the country is exceedingly difficult. A mass of mountains 2,000 feet high runs across, with only a gap here and there. A second hill, called the Allatoona Ridge, of smaller size, lies near the Etowa, and embraces the railroad which goes through it by a small natural gap made by a little stream. This hill stands perfectly isolated, marked only by the division where the railroad passes. It is not broken by any feature; it is not commanded by any adjacent mountain, but forms a strong position of itself. Johston, however, did not choose to defend it. For a sound reason—a reason connected with the covering of the roads, by which he was afraid the enemy might

march on Atlanta; instead of holding that hill at Allatoona he occupied a more woody piece of ground to the South, near the little village of New Hope. In front of that the Federals arrived on the last day of May. About that place, New Hope, there was a series of conflicts, never rising to the character of actions, but being, in fact, severe skirmishes carried on about the entrenchments, and lasting about twelve days. It took twelve days, with the utmost diligence, for a division of Sherman's men to turn the works; the process resembling that of a regular siege more than an open campaign, as we understand it. Sherman at last managed to outflank Johnston. He did it in this way. His previous flanking movement was made with Macpherson on his right. Finding the enemy were guarding themselves there, he extended his own lines, gradually pushed out his left, and making use of Schofield, and being very superior in artillery, he worked the left of his army on until he forced the enemy back and got upon the railroad again, which he had missed for a few miles—from the other side of the Etowa. Then he said "I saw the value of my position, and I determined to make that the base of my future movements." He entrenched it and made it a large depôt of supply, and it became of considerable importance in the latter part of the campaign, as we shall see. For three days, nominally, he rested there, having gained possession of it on the 6th June—three days he calls it, but it was a few more, probably, because it is the 11th before we find the Federals facing the next position of Johnston, which had been taken across the railroad on the Kenesaw mountain. Bad weather came on for the invading army. It was admitted on both sides, and we may, therefore, take it for granted that this had something to do with the delay that followed. Three long weeks rolled on before another mile of progress was made. The works ran close to each other until the men could exchange annoying or insulting messages from one camp to the other, and yet no progress was made. They got so accustomed to entrenching themselves that it was never thought they were intending to fight upon open ground. "All my army," says Sherman, "looked to me to outflank. I resolved to show them that an army must be ready for any purpose for which it is called upon, and I therefore resolved to fight a battle." He acknowledges that motive in the most open and candid manner conceivable, as that which determined him to make an attack upon his enemy's works. It was made on the 12th June, and was very decisively repulsed. His loss was 3,000 men, and the enemy's trifling in comparison; for they, fighting behind their entrenchments only lost, by their own report, 250 men. It seems remarkable that their loss should be so small; but I suppose it may have been possible under the circumstances. Being beaten in his attempt to force the lines, Sherman was more successful in his attempt to outflank the enemy. Leaving Johnston in his works, suddenly he detached Macpherson—for the third time in this campaign—to sweep round past the west of the mountain and march to the rear of the enemy at a place called Turner's Ferry. On the 1st of July that was reached. The Federal chief thought the business was then done. When he came so near the railroad, he

believed that he had cut his enemy off from Atlanta altogether, and that he could, perhaps, destroy him. He acknowledges and does full justice to the extraordinary energy and skill with which Johnston dragged himself out of that difficult position. Entrenching himself as he moved, having but very little choice of ground, the Confederate General fought his way back to the Chattahoochee, and took seven days to make his retreat, so that it was the 10th July before he got finally across the river. The campaign had then lasted two months. Having at last surprised a place of passage on his right, and forced the enemy back in that way, Sherman prepared to force another passage above them on their left, by means of Schofield's army. He rested his troops for a little time, while some part of them—only a small part—were seeking the other passages up the river; and Schofield succeeded at last in forcing the passage some miles above, and passing his troops without much opposition. That was on the 10th July; and at the same time, a sweeping movement was made of that peculiar character which, in modern American warfare, is called a raid, by detaching a large body of cavalry or mounted men—for the latter is more properly the word. On the Tennessee river there is a place called Decatur, near the chief crossing. Just there, as well as at other points along the stream, the Federals had collected a force of cavalry, not connected with Sherman's army; and then under General Rousseau. This officer was directed to cross the whole Northern Alabama, a distance of 250 miles, and to come out upon the Opelika railroad, one of the principal lines that conducts to Atlanta from the Great States on the Mississippi, and to break it up. He started on the 10th of July, and successfully accomplished part of his mission, destroying some twenty miles of the railroad; then making his sweep complete, he moved northward, and joined the army of Sherman, bringing the Federals what they most wanted, a body of cavalry—for they had been fighting with an inferior number of that arm.

I may say a few words as to the breaking up of railroads, as a sort of supplement to the lecture which was given here last year, before a distinguished audience, by Captain Tyler, and I would refer more particularly to the destruction of railroads as carried on in this campaign. The Federals have got a regular and simple system, and a very efficient one. The rails are laid quite open on the woodwork, and the sleepers being exposed, they use a simple kind of lever with an iron grasp at the end of it, which fastens under the rail, a lever by which two or three men pressing downwards, at the other end, may easily bring the rail off altogether. But they have also to take care that if the enemy recover the rails, as is often the case, they shall not make any use of them. They have, therefore, to destroy the rails themselves, and that is done in this way. They light a fire, generally composed of the woodwork of the railroad piled up into a heap. They place the rails across it, and wait till they are red-hot. Then having a couple of wrenches, they fit them round the opposite ends of the rails, and a party of men turn them in opposite directions. In half a minute a rail will be so twisted that it will never be possible to use it again. In

the early part of the war they contented themselves with lighting the fire very high and putting the rails across the top of it, when the heat melted and bent them; but they found afterwards that the enemy hammered them straight and used them again. They now, therefore, adopt the plan above described; and thus, treated, it is simply impossible to straighten them.

This line, then, to Atlanta from Alabama was broken up; and one main line of supply for the Confederates was destroyed. There was a second line, leading to Macon, in the State of Georgia; and a third, nearly due west to Augusta. This latter Schofield had reached, and it was now partly destroyed. Sherman had, however, the problem of getting into Atlanta, being yet only within seven miles of it. Moreover, besides the river itself which he had had to cross, there is a deep stream running on the north side of the town of Atlanta, covering one side of it, called "Peach Tree Creek," which had been taken as a line by Johnston for a new series of defences. Strong works had been made all along the edge of the valley which overlooks that river, and Johnston was prepared to give the Federals another three weeks before they could get across. Neither was there any good reason to doubt that it would be so; for having the same army and the same enemy, and the same circumstances, no man could say that he would not give them three weeks to do *what it actually took them only three hours to do.* On the 17th July, the day when the Federals had made good their passage over the Chattahoochee, Johnston was superseded, and left his command!

President Davis—we have thought him generally in this country a very wise man, indeed, but he has made mistakes—President Davis, it appears, thought Johnston's conduct too slow, too feeble. He had previously had very serious differences with Johnston on other subjects, and he took this as a favourable opportunity for removing him from his command, and putting a younger and more energetic man, a good *fighting* man, who would use the troops more freely, in this place. I happened to have the opportunity of obtaining much personal information from an officer who had the advantage of serving on the staff of General Hood, when he was first distinguished in the campaign of Antietam. I have heard that he is a very brave man, a very energetic man; but I have never heard that his own friends assert him to be a man likely to make a good Commander-in-chief. He thought, however, being put into this command, that something very great was expected of him, and that a much bolder style of tactics would suit him and his army better.

Taking over his army on the 18th July, he withdrew from the Peach Tree Creek lines, and prepared to make a violent attack on the Federals, who had fairly got before the city at a distance of five miles from it. On the morning of the 20th he made a very serious assault upon the centre of Sherman's forces. They had had, however, a few hours to make a slight entrenchment, and owing to that they gave him a decided repulse, with a loss of four or five thousand men. Not satisfied with that, he pushed the whole of his army out of Atlanta two days later, and struck on the left flank of the Federals, which happened to

be open. I should explain that when crossing the River Chattahoochee Macpherson had come out beyond Schofield on the left, whereas, you remember, he had previously been on the right. He fell in the earliest opening of the battle of the 22nd of July, and his death was a very serious loss. I have been told repeatedly by people connected with the Federal cause in different ways, that he was looked upon at that time as the most rising man in their service. He was a man of great ability and industry, most devoted to his men, and very much beloved by them. He had one advantage which we all have at one time of our lives, that of youth. Though in command of an army, he was the youngest General but one in the Federal service; and this advantage of early rank might have been invaluable to him by and by. He fell at the very beginning of the fight, and at first, hearing their loss, his men gave way; but they were rallied by General Palmer, who came up. They succeeded in getting a little cover by falling back, and eventually they repulsed the Confederates a second time, with rather a less loss than on the first occasion. A third time did Hood try this desperate plan of breaking through the entrenchments which his enemy was throwing up all around Atlanta. On the 28th July he made a similar attack, and was beaten again in a very decisive manner by the Federals.

Meanwhile, as all this was going on, Sherman extended his works to the left and right, covering himself everywhere with counter-entrenchments; and the railroad which runs to the eastward of Atlanta was completely destroyed for many miles, and that to Opelika, as you know, had been already injured by the raid that I have spoken of. The result was that Atlanta was dependent for a long time upon the railroad that runs through Jonesborough to Macon. Yet from the 28th July to the 25th of August we find the Federals made no further progress whatever, for the very simple reason that Hood fell back on the old system of acting on the defensive. He took to the very policy that his predecessor had been condemned for. He remained strictly in his entrenchments, and from that time the Federals gained no real advantage. When Sherman went out a mile, Hood went out another mile, running up works to match the others; and this went on from day to day, and the besiegers themselves admitted they were no nearer taking the place. I conceive that that was very much, in his position, a great success. Hood now thought—having heard something of the "principles of war" in former days—that he would make use of them to obstruct his enemy's communications, and bring him back from the siege of Atlanta. So he detached the whole of his cavalry, one of the most formidable parts of his army, to make a sweep and come in upon Calhoun, seize the railroad, break it up, and putting Sherman in fear, make him relinquish his grasp of Atlanta. On that expedition there went General Wheeler and his cavalry; and a more complete failure has not been made in the war. They broke up a mile or two of the railroad here and there without being able to disturb the line of Sherman. They even went up to the city of Nashville, and were equally unsuccessful in Tennessee, ending the raid by being very much harassed and cut up by small parties of Federal horse.

Hood lost, meanwhile, the eyes of his army. Sherman knew the Confederate cavalry had gone away, and instantly availed himself of

it. They had scarcely started when he dispatched his own mounted force on a sort of counter-movement. Finding they were of no use to him in his entrenchments, they were sent round to Jonesborough, to endeavour to break up that one remaining line of railroad. The cavalry generals Sherman had at that time were not very successful. One of them, Stoneman, got beaten, and taken on the way. The other, General Kilpatrick, returned to boast that he stopped all the supplies going into Atlanta, but the next day it was found from deserters that he had done no such thing. Either he had purposely over-estimated his services, or else was very much mistaken. It is certain that Sherman in his report says he was convinced from his own enquiry that it was not the case, and that he could not get possession of Atlanta without trying himself to force his way round to the rear. He was no longer content with raids; he determined to throw his whole army round upon the enemy's communications, and see if that would move them.

He started on the 25th of August, leaving Atlanta with the main body of his army, about 60,000 men. He left 20,000 men perfectly entrenched in front of it to hold the enemy there, the remainder of his 100,000 being either lost or distributed through the garrisons covering the hundred and odd miles of country between Dalton and Atlanta. Every bridge, every station, every important turn of the road for the whole way was entrenched. The telegraph wires were kept in perfect order. If the enemy came across between any two stations and cut the telegraph wires, it was known instantly. Their force was generally in sight of one of the stations; the raid was seen and reported; the enemy was driven off; and what was called a "repair train" being kept ready at all the principal stations, the whole affair was over within a few hours, so that Sherman's communications were beautifully preserved throughout. There is no finer instance of care taken in such matters than in this campaign.

Leaving Slocum then with 20,000 men entrenched before Atlanta in the position which it had cost him two months to win, with his remaining army of 60,000 strong, he cast himself loose, as it were, carrying with him supplies for a few days in waggons, and moved southward, in order to get behind the Confederates. Hood did not see him; having stripped himself of his cavalry, he was not able to discover what his enemy was at. The first thing he knew of the Federal proceedings was, that a large body of their troops had arrived at Rough and Ready, ten miles south of Atlanta. Then he broke up his lines, but too late. His army was greatly diminished, for the three battles had cost him a loss of 20,000 men. His hospitals were very full. His Corps, three in number, were sadly reduced, and when he fought he fought but ill. He tried to do two things—to hold Atlanta, and to attack and beat the army of General Sherman; and in the action which followed at Jonesborough on the 29th August he was decidedly worsted. He was beaten off, and found it necessary at once to evacuate Atlanta. He abandoned, therefore, utterly the attempt to hold it, and left on the night of the 1st and 2nd September. The work of Sherman was thus far crowned with success. I should

observe that of all this time, the only period during which he had been detained by Hood was that, during which the latter stood on the defensive; and from that I cannot help concluding, as well as from the fact that the Federals, under a very able general, well supplied with a wealth of ammunition never known before, progressed from Dalton to Chattanooga only at the rate of a mile and a half a day, that Johnston's strategy, which was blamed at the time, ought to have been most highly praised. Experience shows that his conduct at least was that of a man who knew what he was doing.

The first part of the campaign is now over, and we have done with the lesson derived from Sherman's adherence to the principles of war. His constant outflanking the enemy, and threatening their communications, while maintaining his own free (that is, the communications of the Federals being day by day kept up by the railroad, and completed for the last few miles by waggon trains), had resulted at last in the capture of Atlanta.

But there was another task before him. There lay between him and the Atlantic just that very kind of country which I described in an early part of my lecture, one in which an army might be moved without any communications. It was rich, abounding in crops, intended for the supply of certain Confederate armies collected towards the Mississippi. The able-bodied population had been swept away. The defence of Georgia was entrusted to 13,500 militia, scattered over a large extent of territory. This number seems a mere nothing, and yet it was all there was to oppose Sherman, with the exception of the remains of Hood's army. "If," thought Sherman, "I can only get rid of that army, I can march through this State as I please." He thought it was probable that Hood would endeavour to drive him out of Atlanta by moving on the railroad behind. He judged rightly, and let him go quietly on. He heard whilst he was conversing from day to day, and carefully picking up information and intelligence himself from the inhabitants of Atlanta, that President Davis had been down to the south at Macon making a speech, and stating that in a very few days the Federals would be driven back into Tennessee. Sherman was awake enough to what was meant—that this expression could only be intended to describe generally an attack upon Chattanooga, and upon his communications behind, to be followed by his own retreat: and when Hood suddenly, on the 2nd of October, threw himself across the Chattahoochee, and on the railroad, he allowed him to begin his movement. Still he did not intend that he should damage the railroad much; and as the telegraph wires were so exceedingly liable to be cut, Sherman had taken the precaution to place signal posts on the hills near the stations, from which his men could see and make known what was done. Thus he had a double security; for when Hood's cavalry came and cut the wires, it was still possible to communicate along the whole line. Hood made a dash at the entrenchments of Allatoona on the 5th October, three days after he crossed the river to march straight upon them. The Federals were quickly after him, but not quickly enough, and the place was in great danger; but there was time to signal on from Allatoona to Rome, and a certain General

Corse, a man of known resolution and character, arrived with a succour of 900 infantry just in time, before Hood's cavalry force came round on the north side to intercept him. His reinforcement made the garrison 1,500 strong. They had a hard day's fighting, and were driven out of some of their works; but they maintained themselves to the end of the day, being aware that Sherman was advancing within a day's march of them. Finally, they drove off the enemy with slaughter, after feats of gallantry unsurpassed in this war. They had been summoned to surrender in the words so well known, "to stop the unnecessary effusion of blood." The fit reply of Corse was, that he was "ready to let the unnecessary effusion of blood begin as soon as possible."

The Confederates, after this defeat, now went northward, with Sherman on their track. As the two armies were moving back towards Chattanooga, Sherman thought it was possible that if he made any decisive movement he might force Hood out into the country eastward, which, owing to the conformation of the mountains, would leave him ready to march into Georgia again; whereas, thought he, "If I can entice him to enter Tennessee, and invade the country towards Nashville, it would be better for me; and the way for me to do that will be to appear to march that way myself, as though afraid of his moving on that line." So, about Kingston Sherman turned off into the country on his own left, as if he was anxious to cover Tennessee. Hood then also moved in that direction, threatening Tennessee. The Federals halted. The Confederates halted to look at them. At last, Hood resolved to make a bold invasion of Tennessee, which he thought would have the effect of bringing the enemy back to their original base. When Sherman saw that he was actually moving northward, he began to retrace his steps to Atlanta. Troops were despatched to Chattanooga, sufficient to form a body of 30,000 men, under General Thomas, for the purpose of watching Hood. The rest of the army was speedily collected at Atlanta, amounting, it is believed, to only 50,000 strong, though Sherman's report makes them rather more. Every station from below Calhoun was destroyed; the depôts carried away; and, at last, on the 14th November, Atlanta and all its stores were committed to the flames, so as to leave nothing to the Confederates. An enormous waggon train had been collected and Sherman started off on his celebrated march.

The Federals broke into two columns—Slocum in command of one, the left—and Sherman himself, with the other column under Howard, on the right. The point of concentration being near the little capital of Georgia, the town of Milledgeville. They went on steadily from day to day, living mostly on the country, for supplies were found in abundance. The soldiers behaved admirably well at first, and the officers were strict in their discipline. They could not attempt to carry out the slow and troublesome punishments which have been used in their other armies; they took, therefore, to simple practice of flogging the men on the march, when they misbehaved. On the 14th or 15th of the month the rear guard left Atlanta. On the 24th two columns were safely concentrated at the capital of the State of Georgia.

Near Milledgeville happened the only affair of any importance, for the militia of the State had collected there and made an attack upon Sherman's rear guard. They were brave, but raw recruits. The Federals, who had drawn up behind a slight entrenchment greeted them with a derisive shout of "Come on," knowing they would just venture well under fire, and received them with such volleys that the militia found it impossible to make their advance, and having lost 600 men in a few minutes, ran away. Wheeler had returned from his mistaken expedition to the north, and made an attempt to attack the flanks of Sherman's army and detain them—an attempt that was perfectly unsuccessful. The Federals then broke from Milledgeville into two columns, and made a second march of eight days, concentrating at a great railway junction, Millen. Then, as it was very important to deceive the enemy as to the point they were threatening, which was Savannah, they sent off cavalry to the left to draw off Wheeler in that direction, while the infantry moved southwards on the coast near Savannah, until they came in sight of the sea and their own gunboats. They had accomplished a march of twelve miles a-day, and been abundantly fed on the way, and had kept (as before noticed) excellent discipline for the first few days of the march. But if there can be any one thing more demoralising than another, it is the practice of plundering, as these troops did from day to day, and of burning much that they could not use. They began by burning railroads and stores. They then took to burning all the houses where they heard that bloodhounds had been kept to hunt the slaves; then they carried on the practice so far as to burn nearly every empty house they saw. At last, in North and South Carolina, I am afraid they made a practice of destroying everything within reach.

Be that as it may, on the 10th December Sherman drew near Savannah. He had long contemplated the taking of the great coast cities, Savannah, Charleston, and Wilmington. Having observed that they lay on rivers, the mouths of which were broken into swamps, exceedingly difficult to cross from the shore side, Sherman had long since determined to try the plan of coming down upon their rear. As he expected, he took Savannah with great ease. Making a feint to the left, he threw his right forward beyond Savannah, where there was a little work on Ossabaw Sound, called Fort McAlister. His troops carried that at a single rush. The gunboats communicated with them at once. In a few days they were landing heavy guns, and were prepared to lay siege to the works which had been thrown up around Savannah. On the 19th they began to land siege train from the ships, and on the 21st they were in the city. The war was transferred from Tennessee, an inland base, to a new base on the sea, from which Sherman was at liberty to repeat the operation upon Charleston, and, in fact, to make any number of marches inland. Charleston soon fell on his next movement; and in that way he would have taken Wilmington also, if Wilmington had not fallen before.

Meanwhile what did Hood do? He had entered Tennessee with the idea that he would bring the Federals back out of Georgia. He rushed fiercely northwards on the 15th November, marching on

Nashville. The enemy were weaker and fell back before him. An indecisive battle was fought with their rear-guard at Franklin, in which the Confederates (not for the first time in the war, as some English critics supposed) received a very severe repulse from a force inferior to their own. Finally, Hood forced the enemy into Nashville, and invested that place. It is not easy for 40,000 men to invest another 40,000; and it is still more difficult when there is a railroad behind the enemy, and a river with steamers continually bringing him up fresh troops. The result was, that the Federals got supplies while the Confederates got none; and in a short time General Thomas was the stronger, and came out of his works to attack Hood's army in his turn. I have seen statements lately in more than one periodical, that no instance has occurred in this war of successfully attacking entrenchments; but here Thomas attacked those of Hood, and they were carried. Hood was driven out of Tennessee much more quickly than he went into it, and was only saved from complete destruction by the exertions of his excellent cavalry officer Forrest.

I do not pretend to teach political truths. The object of my lecture is to draw only military lessons from the campaign; but I do maintain that Sherman, genius as he is, has made one or two mistakes. One, especially, although he affects to regard the people of the Southern States as friendly subjects of the Union, yet he has given no voucher or note anywhere for the supplies he has seized. He assumes that his troops have a right to live upon the country, although he assumes also and continually asserts that the people are loyal, if they were only let alone. As it is, they are very often driven out of their houses and homes, and, if their dwellings are happily not burnt, they have frequently nothing else left them. Sad have been the scenes of late, as reports indicate, from the licence of the soldiery in South Carolina. It is possible that there have been scenes there which the North will long regret. I do not pretend to say what will become of these States by-and-by. I hear much of what seems to me but idle talk as to what the South will do in the way of guerrilla warfare. I confess my fears take quite another direction. There are published, constantly, letters from Federal officers speaking of what *they will do* when they hold the country. I know there are instances on both sides—to be numbered by hundreds, perhaps by thousands—instances of such men as the well-known Colonel Dahlgren, whose body after he was killed, was treated with much barbarity by the Confederates, and whose father openly avows his hope of vengeance. Such tales promise sadly to embitter the dregs of the war. There are thousands of men on both sides ready to cry out in grief over their dead, with agonised Northumberland:—

"Let order die;
And let this world no longer be a stage
To drag contention in a lingering act!
But let one spirit of the first-born Cain
Reign in all bosoms; that each heart being set
On bloody courses, the rude scene may end,
And darkness be the burier of the dead!"

His Royal Highness the DUKE OF CAMBRIDGE: I have no doubt that I shall be authorized by those who have attended this lecture to express to Captain Chesney our gratification with the interesting details which he has given of this great campaign. An observation fell from the lecturer which, I must confess, I share with the general public, which is, that it is not a very easy matter to follow the course of the American campaigns. They are so extremely extended, and so extremely disconnected, that it is difficult, even for a practised military student, to follow the campaigns, and it is beyond my weak comprehension; but I must confess that, as far as the campaign which has been just described has been brought before us, nothing could have been in my opinion clearer or more accurate than the description which has been given; and I am sure that we have spent a very agreeable hour in following the course of events which the lecturer has so ably laid before us. Incidentally, I would only remark, as a soldier, that two things struck me very much in what has fallen from the lecturer. One is, that in this war, and, I think, in all future wars, the spade must form a great element in campaigns. It is quite clear, from what has been stated, that there was no movement made without instant entrenchments, both on the part of the attacking force and of that of the defensive; and that even the movements in advance were instantly confirmed, I may say, by the position being entrenched in a manner which would preclude the danger of attack. Now that I think is a very great and new element in the features of war, and probably the necessity for it has been greatly increased by the improvements in arms, both artillery and musketry. An assertion has been often put forward regarding another element in the war, cavalry, which, it has been said, is now become obsolete. Now I think the lecturer has proved to us that that is a fallacy. I confess that I have always had the feeling that I could never understand what was meant by saying that war could ever be carried on without cavalry; and I do think, if there was one feature in the explanations of the lecturer which struck me more forcibly than another, it was that he clearly brought before my mind the absolute necessity of a large, handy body of cavalry, with this difference perhaps, that whereas it was considered in former years that cavalry should be of a very heavy calibre, they ought now to be made as light as possible. There should be masses of light cavalry. Probably the day of heavy cavalry has somewhat passed by. I do not pretend to say they ought to be given up, because to that extent I do not go. I believe that heavy cavalry at a critical moment may be very useful and necessary. But, as to light cavalry, there can be no question that the impolicy of not having such, must be apparent to any one who permits himself to consider the subject. With these few observations, which perhaps it is not my province to make, but which I could not help making, I beg to move that the thanks of this meeting be presented to Captain Chesney for the very able manner in which, on this occasion, he has explained General Sherman's campaign.

The vote of thanks was unanimously agreed to.

Evening Meeting.

Monday, January 30th, 1865.

Lieutenant-General SIR R. AIREY, K.C.B., Quartermaster-General, in the Chair.

COAST RAILWAYS AND RAILWAY ARTILLERY.

By Lieut. Arthur Walker, 79th Highlanders, School of Musketry, Fleetwood.

Abstract.

The advantages of railways considered in a strategical point of view, and their importance as a new agent in warfare, have recently engaged no inconsiderable amount of public attention. Indeed, the subject has already been ably discussed in this theatre, by Captain Tyler, R.E., under patronage at once illustrious and encouraging. But it could hardly be anticipated that a subject so large and comprehensive in its bearings, could be exhausted in one discussion. Although Captain Tyler admirably explained the important functions that railways *had* fulfilled, up to the present time at least, in the late Italian war and the present American contest; he failed, I think, to explain fully their incalculable value to us in *our insular position*, as a means of defence against invasion, whilst we alone have their use in command; he referred to them more as a tool, and not as a weapon; nor did he allude to the available power which they possess in our case, of supplying *moveable batteries for coast defence*, by means of guns fixed on appropriate carriages or trucks, which shall be able to strike a decisive blow at any point suggested by circumstances,—indeed, coming into action like a tropical thunder-cloud in rapidity, and as effective in destruction.

Under these circumstances, therefore, I trust for your kind indulgence, whilst I endeavour to direct your attention to one or two points in connection with the subject, which, to my mind, do not as yet appear to have been at all, or at any rate sufficiently, ventilated.

Of the social and commercial advantages of railways, we are all reminded every day of our lives; but in addition to their value in that

aspect, I do not think that I shall exceed the limits of truth in declaring that railways have as completely revolutionised *warfare on land*, as iron-plated ships have "upset" the whole theory and practice of naval tactics.

And here I must remark, *par parenthèse*, that in using the term "railways," I invariably mean that it should include their grand concomitant the electric telegraph, the wires of which disseminate intelligence throughout our railway system, just as the fibre of trees conducts the sap throughout their trunks (or main lines) to every branch and twig, however remote or minute.

In July, 1860, when the country was in a state of alarm, in one of those invasion-panics which ill beseem the dignity of the nation, and when the best mode of defending London was the all-absorbing question of the day, I ventured to point out in *The Times* newspaper, with what excellent results, railways could be utilised for war purposes in general, and the defence of London in particular.

My idea was that the most economical and effective mode of defence for London, would be a circular railway, forming a complete cordon round it, at an average distance of 10 or 15 miles from its centre, and having for its interior lines of operation, the numerous railways which intersect the space indicated, which would thus form radii and chords to the proposed circle.

During war such a railway, with its electric telegraph, would concentrate an overwhelming number of men and guns at any given point, in the shortest possible time; and, as the whole science and art of war consist "in placing in the right position, and at the right time, a mass of troops greater than those which the enemy can there oppose to you," it follows that the adoption of such a plan would secure a successful defence.

To adapt such a railway to the special purpose which it is intended to serve, it would only be necessary to carry a parapet of earth along the entire length of its outer edge—to have numerous "sidings and switchings" at regular distances—to have Armstrong and Whitworth ordnance mounted upon large iron-plated trucks, and to have those trucks fitted with traversing platforms and shot-proof shields, so as to act as so many moveable batteries—and to have railway carriages with shot-proof sides, duly loopholed, for the conveyance of troops and sharpshooters.

During peace such a railway would be available for the purposes of traffic and passenger locomotion, and so yield at least some return for the capital sunk in its formation, besides being the means of relieving the metropolitan thoroughfares from a very considerable portion of that prodigious carriage work by which they are oppressed. Indeed, there can be no doubt that the plan would "pay" as a commercial speculation, being at the same time a vast social benefit, and a national work as grand as the fortifications of Paris, but far more useful in every way, besides the main point in question—the defence of London.

Such is, in substance, the proposition I then brought forward; and it is remarkable that the principle, in its restricted sense as applicable to London, has received a two-fold development in the scheme proposed

last year by Mr. Fowler, C.E., for uniting the metropolitan traffic by *two* concentric circular lines of rail (the Bill for one of which has, I believe, been officially approved of, and will therefore be adopted); whilst the soundness of the plan in a general sense, as applicable to strategy, has been established in a remarkable degree by the course of events during the last few years in Italy, America, and Denmark, proving its advantages where it existed, and demonstrating the cause of disasters by its absence.

It is now, I believe, indisputable that the effective co-operation of a railway, and its exclusive use, are equivalent to doubling the force that possesses it. For example, it is pretty generally admitted that if the railway which was in course of construction along the rear of what, alas! was the Dannewerke, had been completed in proper time, that work, with all its valuable equipments, need never have been abandoned by the Danes. In fact, such a railway would have been tantamount to an addition to their forces of 20,000 men—40,000 being the proper number admitted to be requisite for the efficient defence and maintenance of the work in question. This conclusion is based on a leading principle in the art of war, that it is always advisable "to maintain as extensive a strategical front as possible, because it keeps the enemy in doubt as to the points on which we intend to strike a decisive blow; yet the distance of that strategical point must never be incompatible with the maintenance of our interior lines, hence superiority in the rate of marching becomes of immense advantage. If one army can move twice as fast as another, its divisions are positively on interior lines when eighty or ninety miles apart, with respect to the enemy, when his divisions are only fifty miles apart."*

Viewed in this light, and looking at the numerical inferiority of our army as compared with the forces of the great Continental Powers, railways become to us a positive necessity as a means of defence against invasion; and by their proper utilization, our insular position is thus evidently convertible into a source of safety and strength, and we have the vantage ground against all Europe combined, if we only use our modern appliances.

Now I contend that, after her fleet, England can possess no better or more strategical line of defence than railways, constructed more or less within a short parallel distance of her entire coast line. By means of these, a vastly preponderating force of *men and guns* could be concentrated at any point along the coast in a much shorter space of time than that in which a hostile fleet, propelled by steam, could take up a position, far less, effect a disembarkation. Such a system of coast railways would indeed be to England—

> "In the office of a wall,
> Or as a moat defensive to a house,
> Against the envy of less happy lands."

In order to effect this object as far as attainable, it would be desirable that a strategical survey should be made of our existing coast-lines, with the view of having (where it may be necessary, for in many direc-

* Colburn's "United Service Magazine."

tions the rock-bound nature of the coast presents an insurmountable barrier to any attempt at landing) the intervals now intervening, filled up more or less, either with a regular line of rails or a cheaper description of tram-road, so as to girt the island with an unbroken circle or iron *cordon*, having radii branching out to meet it in every practicable direction. This would impart a homogeneity or specific purpose to our present disjointed railway system, such as would permit of its being at once adapted to the exigencies arising from any attempt at invasion, and facilitate that rapidity of centralization, of action, and precision as to time, which are so essential for the successful development of military movements.

I do not mean to say it would be practicable, or indeed desirable, to make such a line follow every sinuosity and indentation of our coast, but when it is borne in mind that the Royal Commission, which sat some time back on Coast Defences, then stated that even after their recommendations for fortifying certain portions of our coast had been fully carried out, there would still remain on our southern and eastern shores upwards of 300 miles of undefended coast, not to speak of the many more hundreds of miles of the northern and western sides of the island left defenceless, the necessity of doing *something* towards consolidating and uniting our coast railways into a comprehensive system, adapted for strategical purposes, becomes more apparent, especially as in warfare the strongest point in a defensive line is only equal to the weakest.

A glance at any railway map of the kingdom will at once explain my meaning. If the eye be directed to the coast of Norfolk, for instance, it will be observed that between the railway terminus at Yarmouth in the south, and that at Wells in the north of the same county, a hiatus of coast intervenes, which, stated roughly, borders on 60 miles, without a vestige of railway communication. It would thus be equivalent to something *like a two days'* march before a force, starting from either terminus, could reach a point mid-way.

Now, during those two days, what might not a well-organized force of invaders, supplied with every modern appliance for disembarkation and subsequent engineering, do either in the way of disembarking on a coast so accessible as that of Norfolk, establishing their position in that county, or in prosecuting their march on London, the possession of which would, after all, be the grand aim and objective point of e ry invading army.

This is only one of the numerous instances of a similar kind that might be pointed out to illustrate the defective state of our present railway arrangements in a strategical point of view.

Of course it would be absurd to expect that Government or the country should, regardless of cost, at once commence to plant railways round every inch of sea-board; what I maintain is, that it should be a recognized principle on the part of every Government that every railway undertaking which abuts on the sea coast, and forms, as it were, a link, however small, in the great line of defence here indicated, should receive their encouragement and support.

Land almost where you will on the continent, and a railway is to be

found running along the shore. In Italy a magnificent line of railway is being constructed along the entire coast, embracing, in addition to its highly commercial character, all the important strategic desiderata I have endeavoured to point out, and this line has been named the "Victor Emmanuel Railway."

France, of course, has made the strategic consideration of her railways one of paramount importance, and it has been asserted that "by means of the central railroads of France, it would be easy to collect on one point, all the *matériel* required to fling 30,000 men upon the frontier with the utmost rapidity. The departure would be from different starting-places, at least for the cavalry and artillery; as for the infantry, it can start from any point. The convoys would start at intervals of twenty minutes, one after the other. At the end of every 22 miles (35 kilometres) the locomotives should stop to water; that would be about every hour. As soon as the convoy reaches its destination it should immediately return, to be followed by a second, and so on. All will depart in the same order, and a continual movement will be established on both rails;" "and in the space of only two days," says General Redmond, "a corps of some 20,000 men, like those clouds which a strong wind wafts from the south to the north, or from the west to the east, might advance on its iron roads from one of our frontiers to the other; and as we can almost always protract a strategic operation for nearly a week, this detachment, without compromising the operations of the army from which it is drawn, might, during that time, take part in *two* battles, one of which might be fought on the German frontier, and the other on the Spanish; or one at the foot of the Alps, the other on the shores of the ocean."

Captain Tyler, in his paper on this subject, has given a comprehensive summary of the number of troops, with their stores and ammunition, that could be despatched by rail in a given time, according to our English system; and it may not be without profit, or for the sake of comparison, if nothing more, to consider the French method of military transportation, in this respect, as given by a writer previously quoted:—

"A convoy of moderate strength, namely, about thirty carriages, with a locomotive travelling at the rate of 24 miles per hour:—carries, 1. Of the infantry, 28 officers, 939 men, 3 or 6 horses with baggage, in fact, a battalion for active service, with a fraction of the staff. 2. Of cavalry, 8 officers, 192 men, 160 horses and baggage, that is to say, an entire squadron, with a fraction of the regimental staff. 3. Of the artillery, 2 officers, 109 men, 110 horses and 16 carriages, amounting to half a battery. 4. Of the train, 2 officers, 99 men, 105 horses, and 22 tumbrils.

"Such are what are called the 'units of transport.' There are, besides, the special arrangements for the different arms. For the infantry, luggage trains or third-class carriages are used, each compartment adapted for 10 travellers, receiving only 9 soldiers, so as to have one vacant place for bags and arms. For the cavalry-transport, the horses are placed in the bullock-waggons, pressed close to each other so that they cannot move; this is the best mode for preventing

accidents, 3 or 9 being placed in each waggon. As the horse carriages can only contain 3 horses, they are of little service for this purpose.

"The men are seated on stools or hammocks at the head of their horses, the saddles are in the luggage-waggons, each waggon containing 60. In short distances the horses travel saddled and packed. The train also carries a wooden bridge to serve as an inclined plane, and permit the landing of the squadron at any point of the journey. The horses eat hay during the journey, and get oats on their arrival.

"For the artillery the arrangements are similar as to the men and horses. The carriages are placed on trucks, platforms of various dimensions, but two of which generally suffice for three carriages. The first waggons should always be those of the men and horses. The caissons are placed in the rear, because it has been observed that the burning sparks of the locomotive scarcely ever reach beyond the seventh or eighth carriage.

"Moreover, frequent inspections take place during the journey, to see that the powder is not sifting. When possible, the carriages are tilted. Lastly, the waggons are marked with chalk so as to secure ready access to the various elements of every piece. An appliance for unloading the waggons is also provided.

"Such are the general arrangements for the transport of troops, and they prove the possibility of transporting a *corps d'armée* by rail. For instance, for a corps of 25,000 to 30,000 men, there will be required:—

For 30 battalions..	30	convoys.
,, 16 squadrons..	16	,,
,, 10 batteries..	20	,,
The baggage	15	,,

"In all, about 80 convoys, and, consequently, 80 locomotives and 2,400 carriages."*

Railroads may thus be seen to confer a power of ubiquity to troops generally, and I shall now proceed to point out the great utility to which they may be especially turned, with respect to an arm of the service to which modern warfare must necessarily assign a far more important part than heretofore—great as that has always been especially in the wars of Napoleon—I mean the artillery.

Our own experiences in China and New Zealand, together with those furnished by the American contest, serve to demonstrate that, when defended with our present rifled artillery, no open position has yet been successfully attacked. In the open, the Armstrong shells have proved simply annihilating.

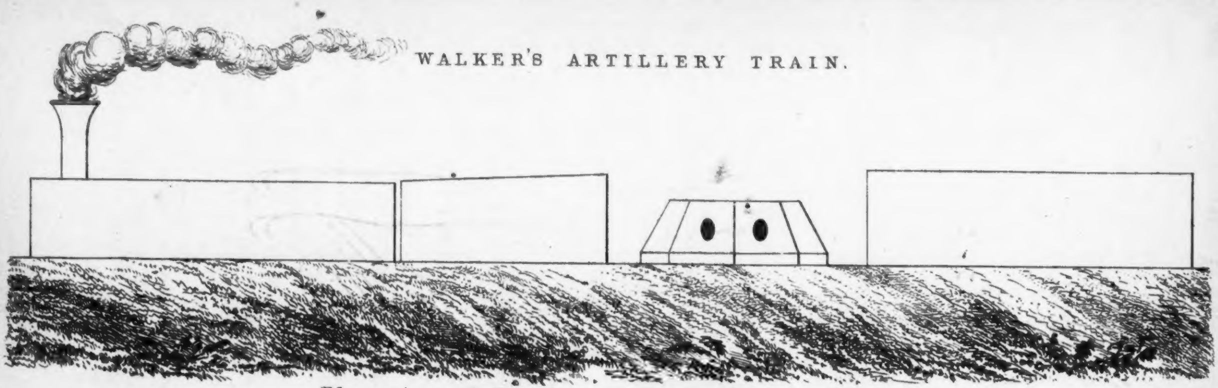
It may be superfluous to state that there are two kinds of artillery—guns of position and field guns.

The first, on account of their weight, are usually posted at certain points which they are intended to occupy permanently during an engagement; although, of course, it is a great advantage to be able to manœuvre them.

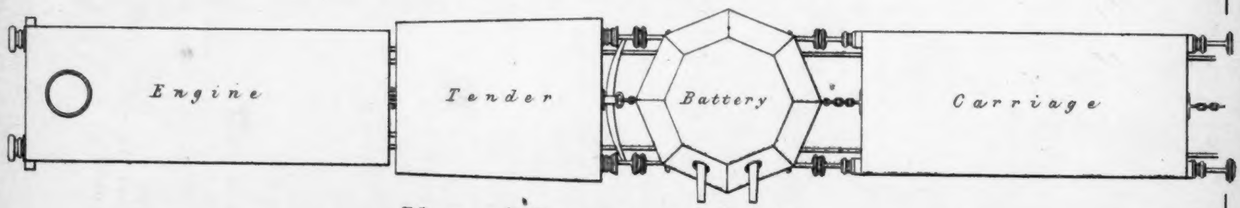
On the other hand, field artillery has the disadvantage of requiring

* "Steinmetz on Great Maritime Invasions," Colburn's United Service Magazine.

WALKER'S ARTILLERY TRAIN.



Elevation of Portion of Train in Embankment.



Plan of Portion of Train.

SCALE OF 0 1 2 3 4 5 10 15 20 25 30 FEET

J R Jobbins

many horses to draw it, and these horses, when wounded, become useless as a motive power, besides being impediments, whilst it has the further disadvantage of being open to the flanking attacks of cavalry, whose greater speed prevents the guns getting away successfully.

The question, then, which presents itself is, how to dispense with horses as a motive power, on the one hand, and how to impart a power of mobility to large guns of position, on the other, without loss of time in doing so.

The mode of procedure proposed by me in a letter to the "Times," dated 12th August, 1864, was somewhat as follows:—Place our artillery upon our true lines of defence—our rails—and have it drawn or propelled by steam. For example, let two rifled guns be mounted on a railway truck, fitted with a circular traversing platform, which supports either a hemispherical or frustrum-shaped iron-plated shield, this may be of the form shown in Plate XXII, which shows a transverse section of a line of railway with a battery thereon, on the principle identified, with the well-known name of Captain Cowper Coles. A truck on eight wheels would carry all this very easily, and permit its own sides to be encased in a cuirass of sufficient thickness; for, in speaking of iron-casing in this instance, it will only be necessary as a rule to consider a thickness sufficiently shot-proof against field-artillery, since it is hardly to be supposed that an invading force would—at any rate at first—have any heavier ordnance at hand for the purpose of attack. Wherever the nature of the ground permitted, a parapet or breast-work would be thrown up on the sea-board side of the railroad, nearly as high as the muzzle of the gun, so as to form a sort of glacis, and effectually screen the wheels and other parts of the battery as may be seen by Plate XXIII.

The "training" of the guns would be effected by turning the shield itself, together with the guns, gunners, and platform on which they stand; so that, to use the words of Captain Coles, in describing his turret-system in this theatre, "the whole apparatus thus becomes as it were the gun-carriage, and being placed on a turn-table, it can be revolved to the greatest nicety of adjustment by means of a winch, or of handspikes at the circumference."

The steam-engine with its tender would also be protected by an iron cuirass, and placed between two cupolas for further protection. Thus Plate XXII represents the elevation of a battery as intended to be carried on a line of railway having two rifled guns, either breech loaders or muzzle loaders, the number of which could be arranged at will, according to the amount of steam power at command. A plan view of the same is represented beneath on the same plate.

It would be practically a moving fortress, carrying with it provisions and ammunition enough for men and guns. There would be no horses to take fright, to be killed, or to be fed. No cavalry could approach it, nor artillery reach it with effect. It could, after firing, move out of its own smoke into a clear atmosphere, and after *enfilading one flank* of the invaders with its fire, it might—before they had recovered their *morale* —repeat the dose "in the twinkling of an eye," or rush off to *find* a more *vulnerable flank*.

To attempt to land in the face of such a destructive weapon of war as this, would be simply impossible. Its *cross fire* would *rake the* boats as they approached, and smash them to atoms. One such battery, so mounted and fitted, would have effectually prevented the Allies from landing at Old Fort in the Crimea.

Moving batteries, as described, would be the cheapest of all possible fortresses. They would in fact constitute a continuous fortress along the entire coast—thus dispensing with any "towers along the steep." We have hitherto regarded the rail merely as a vehicle of transport, to carry materials which are not to be employed till off the rails. But we now see that railroads may be made instruments of warfare without any loss of time being incurred, but the converse. They are to an army what the marine engines are to a steam-fleet; and we are positively startled at the enormous means which these great commercial undertakings offer us for the purposes of war, either for the offensive or the defensive—but more especially the latter. In one respect, however, they differ essentially from all other warlike appliances, whose only purpose is destruction; for, they are capable of being immediately re-converted to the peaceful purposes for which they were originally designed. Never before did peace and war go hand in hand more effectually together. We have absolutely nothing to do but to improvise well-adapted gun-carriages for our rails; our steam-horses are ready and joyously "smelling the battle afar off—the thunder of the captains, and the shouting," and our passenger carriages could with the slight addition of loop-holed iron-plates attached to their sides, become as it were moving block-houses, in which our soldiers or volunteers could be carried, and find shelter if hard pressed, and keep up a galling fire of musketry. Thus circumstanced they would be in position ready for attack or defence, in an instant, without any time being lost, as usual, in getting out of the trains.

That some such arrangement for endowing a railroad train in time of war with a certain power of self-defence, apart from any consideration of offence, has been abundantly demonstrated in the present American War; where often valuable trains have been captured by petty detachments of cavalry, simply because they lacked any power or means of resistance; now by the means I have suggested, such a contingency would certainly be prevented, for although unable to sustain a regular siege, any train would certainly be able to hold out long enough, in most cases to permit of reinforcements being brought to its relief.

Such is a general view of this great prospect before us in the all important matter of national defence against invasion.

One of the first objections certain to occur to a practical man in respect of these moving batteries, is the effect of recoil on the trucks. Now on this point, Captain Coles (and no one will say his is not a *practical* mind) has assured me that the weight of the cupola, turntable, truck, &c., would be so great in proportion to the gun and projectile that the recoil, which in these turrets would also be gradually checked by an inclined plane and buffers, would not actually be felt. But even were it otherwise, I believe any evil effects likely to arise from it could be obviated by simply adopting a moveable prop or stay

(as shown in Plate XXIII), which could be let down so as to act as a sort of stay or support on the reverse side of the truck, when the gun was being fired at right angles, say to the line of rails, and thus prevent the possibility of the gun-carriage being unshipped from them by the jar of the explosion.

But in practice, I believe it would become apparent that no such appliance was called for. This direct fire can never become absolutely necessary; and owing to the manner in which the guns are mounted on turn-tables, &c., an oblique fire would not only always be practicable, but more desirable, because it is more likely to be more effective. For if the guns are of large calibre they would be of great length as well as weight, and therefore, they could not well be used at right angles to the rail, but would have to throw their shot over the "quarter" or over the "bow," *i.e.*, diagonally to the truck frame. Now oblique firing could not be attended with the disastrous effects of recoil alluded to. It is obvious that when fired within a certain arc, the exact limit or degrees of which would have to be before determined by calculation and experiment, any recoil from a gun so mounted would merely act as a propeller to the train in an opposite direction along the rails.

Another objection is that the nature of the ground on the coast, would at times prevent the formation of a railway, according to our ordinary acceptation of the term, owing to its unevenness; but so that no link in the chain of defence should be wanting, Mr. Bridges Adams has suggested that cheap tramroads could be made to follow the surface of the ground where roads exist, by simply sinking the rails to the level of the road-surface, in such a mode that the ordinary uses would not be interfered with. The usual gradients on ordinary turnpike roads are about one in twenty, and many coast roads run very near the shore, or the edge of the cliff, as observed by the same writer; and he then proceeds to describe the method that appears to him best adapted for uniting the existing lines of railroads proper with these extemporised tramways, and coming from so eminent an engineer the details are worthy of consideration. Assuming the gradient to be one in twenty, a locomotive engine on four low driving-wheels, and weighing, with full load of fuel and water, only fourteen tons, would be competent to draw behind it, or propel before it, eighteen tons of load, at a speed of twenty miles per hour. A truck on four wheels, weighing six tons, could carry on a railway platform a long gun weighing five tons, and throwing a fifty-pound shot four miles. A second truck could be walled round with sheet-iron, to shelter the gunners, and weighing, say three tons, with four tons of ammunition; or instead of a single gun of five tons, carriages and men being also increased, five guns weighing one ton each might be applied. Supposing the gradient to be one in forty, the same engine could take a battery weighing forty-six tons at the same speed; and with a gradient of one in eighty, a battery weighing ninety tons. Therefore, ten locomotives, worth probably £1,500 each, would be the moving power for a battery of ten 50-pounders, up a gradient of one in twenty, at a speed of twenty miles per hour. Horses would be entirely dispensed with, and the speed of movement doubled, with an expenditure of coal about one-tenth the value of oats and hay; and, moreover,

coal being only required when in use, and not constantly, as in the case of oats and hay.

It seems also that objections have been raised in a military point of view to railways bordering on the coast, on account of their liability to be shelled; but the objectors forget that in our day it is quite as feasible, if not more so, to protect the guns and carriages of a train such as before described, with iron plating rendering them shot-proof, as the sides of ships of war; and as those moveable iron-plated forts —for such they would amount to—would have a good command over a coast line in front, it is not too much to suppose that they would try their hand at shelling likewise, perhaps with as destructive an effect as that of the Russian field battery at Odessa against H.M.S. "Tiger."

It is of paramount importance in a strategical point of view that the Government should have some voice in the planning, disposal, and arrangements subsisting, or which should subsist between the railways throughout the country; so that should an emergency ever occur, we shall be in a position to utilize them in every sense *pro bono publico*—that is, for the nation's honour, defence, and safety. "It appears to me," writes Admiral Sartorius to the *Times* (May 19th, 1864), "that in every future concession for new railroads, their *strategical* use should always be kept in view; and the second and third class carriages be so fitted that without interfering with their ordinary uses they should be prepared to carry, when required, the largest possible number of troops. Three or four days in the course of the year might also be used with advantage by volunteers, regulars, and artillery in practising how to embark and disembark from railways so as to insure effectiveness and expedition in the hour of danger."

Most assuredly then, the *defence of the country* is not the least of the problems to be solved in laying down railroads. Local interests and the interests of railway companies may scoff at the laws and suggestions of strategy; but when war comes upon us, few will have more at stake on that occasion than these very companies and local interests.

But it may be asked—why should we trouble ourselves about such a matter at the present time—seeing that we are at peace with all men?

The security resulting from what are called "amicable relations" on all sides, has not been a sufficient reason to the French for not looking forward to future contingencies which might entail, as of old national discomfiture. Their preparation in the admirably planned strategical resources of their railways—their centralization and military management—all prove the wisdom of men made prudent by experience dearly bought, and determined to turn every appliance of modern art and science to account against a repetition of former disasters.

Whilst favouring to the utmost the extension of commerce, the transport of bales, boxes, and passengers, they look keenly to the time when France may again have to wrestle with grand coalitions similar to those which formerly taxed her energies to the utmost, and finally dictated to her the terms of an ignominious peace in her

captured capital—her Emperor exiled—a large indemnity levied—and her chief cities or fortresses garrisoned by foreign troops to her own cost and discomfort. France rightly says—I shall not have that again, if I can help it—and I take my measures accordingly.

But, with regard to ourselves, it is not the *probability* but the *possibility* of invasion, that must be considered. The possibility is the nurse of our unseemly invasion-panics. It is also a temptation to the invader. If we are fully prepared at all points, there never can be an invasion, because the futility of the attempt will be most evident to those who are most competent to judge of military chances of success and failure.

In conclusion, apart from that serious question of national honour, security, and independence, it is surely desirable that an island like Great Britain should have an iron high-road running parallel with that other "silent highway," the source of all our greatness, the ocean, our time-honoured "moat and circumvallation." So that the two may mutually become feeders, and supports to each other throughout the length and breadth of the island. As I before said, land where you will on the continent, a railway is to be found running along the shore; and shall we islanders, who, to use the words of Garibaldi, "would rather disappear under the ocean, than allow our country to be violated," fail utterly to perceive how essential coast railways are to our *political* as well as our *commercial* existence?

Then let us put this "girdle round about" our isle, and remain for ever prosperous, secure, independent, and indomitable, because "semper parati." So that,

> "Come the three quarters of the world in arms,
> And we shall shock them."

WRIGHT'S ARTILLERY RAILWAY AND GUN CARRIAGE FORMING A MOVING AND FIXED RAILWAY TRAIN BATTERY FOR COAST FRONTIER AND INLAND DEFENCES.

By Mr. T. Wright, C.E.

Any proposition which has for its object the protection of the lives and liberties of the inhabitants of a country, is at least deserving of some considerable attention.

In the protection of our country from invasion it is obvious that as we are entirely surrounded by water, any attack made will be from the seaward, consequently our chief aim must be to render our coasts as secure as possible. It is well known that fixed forts and Martello towers are all but useless for this reason, that as they are placed at some considerable distance from each other, there is plenty of room for an enemy to effect a landing between them. We require, then, some system by which men and artillery may be rapidly brought to bear upon

the invaders. Railway communication appears to me to offer the best means of escape from the difficulty, but under ordinary principles of construction it would be open to many objections. These objections I have endeavoured to overcome by the following simple mechanical arrangements:—

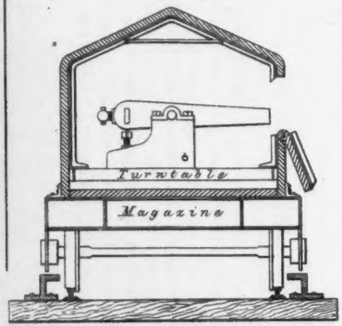
It is my usual plan to divide accidents by railway into three heads, viz., *Running off the Line*, the *Breaking of Axles and Springs*, and *Collisions*. Any one of these would be sufficient to defeat the object of the expedition. To overcome the first, I propose to lay a kerb sufficiently near the wheels to admit of the carriages running clear of it, so that should any of the wheels mount or leave the rail, they grind against the kerb, and so are brought back to their places.

The breaking of axles and springs is thus guarded against; inside the kerb runs a long groove, about the height of the axles, and in that groove, works an L-shaped piece of iron, or life guard, bolted to the carriage, so that should all the wheels be struck away, the carriage would slide like a sledge, until it brought itself to a standstill. *Collisions* are more difficult to deal with, as they are invariably the result of carelessness on the part of the officials, but when an accident is likely to occur, it is but right that the driver and guard should have the best means placed at their disposal for preventing it and bringing the train to a stand in the shortest possible space of time. Overhanging the kerb, and tied across by a transverse bar of iron, sliding in grooves in the L irons, or life guards, are pieces of iron plate, shod with soft wood. By turning a handle similar to the ordinary break handle, these pieces of wood are pressed upon the top of the kerb. The tongues of the life guards biting upon the under surface, thus offer immense resistance to the forward passage of the train.

One difficulty would probably suggest itself, that is, how a train having kerbs upon either side of it, can shunt from one line to another. This is effected by cutting gaps in the kerb, sufficient to allow the engine to pass. The artillery railway, with its skid break, kerb, life guard, and gun carriage, forming a *moving* or *fixed* railway iron train battery for coast, frontier and inland defences, is shown by the transverse sections, Figs. 1, 2, 3, on Plate XXIV. Such train batteries can be used effectively at any part of the coast where an enemy threatens to land, thus rendering a service which no fortification can afford. The train consists of a locomotive and several carriages, coupled together by suitable means, on each of which is mounted a mortar or pivot-gun, which can be trained on any object in any possible direction, by means of turn-plates, moving on the truck platform. With such a train of artillery, any departure from the line or accident would be fatal to its utility, but it will be seen from my foregoing remarks, that accidents of every kind have been guarded against. As every truck forming the train, carrying its gun, ammunition, &c., becomes as it were a fighting deck, precautions are necessary to counteract concussions and recoil, resulting from firing, and this is done by placing a substantial India-rubber packing underneath the platform on which the gun rests. But even this would probably be insufficient to prevent the springs of the carriage being shattered when the recoil took place.

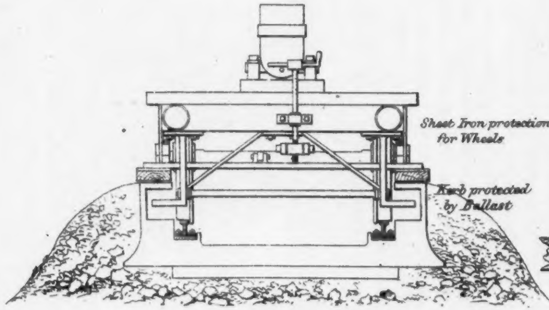
WRIGHT'S RAILWAY ARTILLERY IRON TRAIN BATTERY.

Fig. 1.



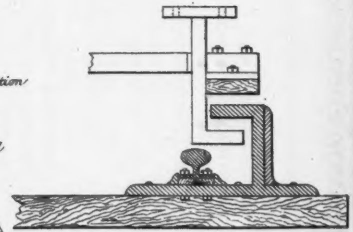
Transverse Section of Railway Iron Covered Gun Carriage for one or more Guns.

Fig. 2.



End View of Mortar Carriage to be protected by Embankment, Wall or Breastwork Seawards.

Fig. 3.



Sectional View of Skid, Clutch and Life Guard.

J. R. Jobbins.

That there may, however, be no risk, the breaks are brought down upon the kerb, and the whole weight of the carriage thrown directly upon them. The tongue of the life guard being at the same time raised and pressed against the under surface of the kerb, fixes the carriage firmly to the road. Other provisions can be made to overcome the recoil by inserting springs behind the trunnions, and by an inclined plane under the carriage itself. The action of the breaks is extremely simple, two or three turns of the handle by the gunner standing upon the carriage being sufficient to raise the carriage off or to replace it upon the rails.

The ammunition, &c., is carried in a hold or magazine underneath the platform and deck of the carriage, where it can be easily got at, its *vis inertiæ* assisting to counteract the concussions and recoil of the gun.

The gun carriage is made entirely of iron, and is either *uncovered* or *partly* covered, but when entirely covered is like a railway horse-box, with fall-down sides or portholes. A battery of several guns may also be placed in one long carriage, if desirable.

The train battery can be made up of 10, 20, or 40 guns or mortars, at the discretion of the officer in command, the trains, if necessary, being also increased, the rapidity of movement, economizing time, men, and materials. With regard to the guns used, they may be either muzzle or breech-loaders, and, in order to protect the wheels, axles, &c., from injury, iron plates are fastened to the underframing, while the kerbs are protected by ballast carefully packed against them.

The guage would be the same as that of ordinary railways, to which my plan can alike be applied, so that trains could pass from one line to another; by this means the trains might be used for inland defence. The Government would doubtless construct military railways of their own, and in this case embankments or walls might be made along the most open parts, for the further protection of the line.

Mr. Wright: If you will allow me, I will now explain my 10-gun battery. I have placed 10 guns there, but any one may see that the train may be made up of 30 or 40 carriages with guns, and also that the batteries may be increased to three or four trains, forming a line of batteries nearly a mile long, and delivering a broadside of 150 or 200 guns. A model of the carriage is on the table before you. The interior of the carriage or hold forms a magazine. There are two man-holes, which make it accessible for the men to descend into the hold of the magazine to bring up the ammunition. It is also obvious that the gun is capable of being elevated or depressed to any point that is required by the officer in command. The gun carriage is placed upon an ordinary turn-table, which you see can traverse in any direction. This turn-table is placed upon a wrought-iron platform. Between the platform and the deck of the carriage is an elastic medium, in order to counteract the concussion and recoil of the gun. Of course, beneath this is the magazine. Now, this carriage so arranged, will either form a moving or a fixed gun carriage, by simply turning a handle, and by having it long enough you can place one, two, three, or four guns upon it. It is evident that with a few turns of the break handle the men can, at the word of command, bring the carriage up and fix it. There is a break handle at each end of the carriage. If the officer in command wishes to have the carriage fixed, he simply takes the weight of the carriage off the springs and the wheels. But it must be understood that to provide for the recoil of the gun is of less importance than to protect the wheels and springs from the effects of concussion. It is also obvious that in going into action, any accident, such as ordinarily occurs on railways,—for instance the engine and carriages running off the line, a wheel mounting the rail, the breaking

of an axle or the breaking of a wheel, or a collision—would defeat the object of the expedition. Now, I think I shall be able to show you that I have provided against these contingencies. In the first place, here are two ordinary rails, say, similar to those on the Great Western Railway, no matter whether the 7 feet guage, or the 4 feet 8½ inches guage. On each side of this rail is placed a grooved kerb. This kerb is placed about 9 inches above the level of the rail, and close to the wheels, but so that all the wheels can travel freely backwards and forwards. Directly a wheel mounts the rail and grinds against the kerb, it rights itself and comes back again. In going to Brighton, for instance, the wheels might be so running off the rails a hundred times, and passengers not know anything about it. That important provision is the first object that should be attended to, and also in order that when a gun is fired, the concussion will not have the effect of lifting and swerving the wheels off the rails. In order to support a carriage when an axle or spring breaks, I place what I term a "life-guard," a kind of crutch or L-shaped support, one at each corner of the carriage, the tongue of the L-shaped support travelling in the groove of the kerb. Were the four wheels struck away by a shot or broken in any way, the carriage would thus travel confined in a groove. The kerb groove is about 6 inches deep; the tongue of the L travels clear 3 inches within the groove. The moment that the wheels are shot away the carriage becomes like a Russian sledge. The "life-guards" also prevent the carriage from tilting over during the concussion of the gun, or if a coupling broke, the combined action of the life-guard and break, griping the top table of the kerb, by two or three turns of the break handle, would bring the carriage up again and fix it firmly to the kerb. Then, in the next place, to prevent a collision, I place a cross-bar through two opposite guards, which works up and down in an elongated opening. The end of that bar is shod with about 2 feet of timber, which gives a large frictional bearing upon the kerb, and also acts as a break, giving about 144 square inches of wood friction surface, acting directly upon the top table of the kerb. The kerb answers a three-fold purpose: 1st, it keeps the carriage on the line; 2ndly, it supports the carriage or train when a wheel or tyre breaks; 3rdly, it breaks the impetus of the carriage in the shortest possible time. It would, I think, do much to preserve the lives of passengers if attached to ordinary railways. Looking at that train in the diagram you will see that all the carriages are open; and in this way you could have a fighting deck of forty carriages, each 20 feet long or more, communicating with each other. Admiral Sartorius and other gentlemen are advocates of uncovered carriages, they do not like the dangerous shot splinters flying about; field artillery carriages are entirely uncovered: perhaps in practice partly covered railway gun carriages would be preferable, the same as shown in the model upon the table, but some might prefer them with iron fall-down sides or port-holes. You see that gun on the carriage is entirely covered by iron and timber. The men before an enemy would be placed under a shot-proof shelter. The trains could travel 30 or 40 miles during the night to protect any point of the coast that might be threatened. My principle of kerbs can be applied to any existing railways for about £1,500 per mile, and for military Government railways exclusively, and made entirely of iron, for about £3,000 or £4,000 per mile, single line. The kerb can be laid down upon the sleeper road in lengths of twelve feet, the same as stone kerbs alongside the streets of London. The tongue of the life-guard L, travels in the groove of the kerb, and directly an accident occurs it falls down to the bottom of the groove, and slides along. In the concussion or recoil of a gun on a battery carriage, it would lift the tongue up to the under side of the top table of the kerb. No shot could strike the kerb, because it would be backed up with ballast. The wheels are protected by iron plating, and the railway can be protected seawards by embankments, breastworks, or walls.

The Chairman: How do you take up the recoil?

Mr. Wright: I place an inclined plane behind the trunnions, and a spring behind each of them; also traversing slides between the gun carriage and upon the turntable, in addition to cushioning the whole with all elastic medium of India-rubber under the platform of the carriage. When this is tried in practice there is no doubt that the springs, in addition to the provision for the recoil, will be ample, and could be shown in a larger model. This model is intended only to illustrate

the general principle. It does not go into the *minutiæ*, or into the mechanical details, but only into the main points, which are the keeping the engine and carriages on the line when going into action and during the concussion of the guns; also in case of the destruction of wheels, or the breakage of axles; and the bringing the carriages up properly to prevent collisions; it shows also the general mounting and working of the gun upon the carriage, with its interior magazine, &c.

The CHAIRMAN: Have you made any calculation about bringing up the carriages, supposing you are going at a speed of 30 miles an hour?

Mr. WRIGHT: I have not made any calculation, but I know what has been done with my skid break, instead of applying the breaks to the wheels in the ordinary way, this break, about two feet long and six inches wide rubs on the top of the kerb. The railway wheel being round, gives little biting surface upon the rail, and when clamped the two rubbing surfaces being metal, there is very imperfect retarding action of only about a square inch to each wheel, or four square inches per carriage; but in my skid break there are 144 square inches of a timber block biting upon the iron kerb on each side of the carriage, with the whole weight of the carriage pressing upon them. In dry weather we know that the ordinary railway wheels, with their breaks upon them, run merely like so many skates.

The CHAIRMAN: The ordinary wheel bites at only one point, while your skid break bites with its whole surface?

Mr. WRIGHT: Yes. Four ordinary wheels give only four square inches per carriage, while the skid break gives 288 square inches per carriage of frictional retarding surface, enough to bring the train up directly; and it answers the purpose not only of being a break, but also of securing the carriage to the railway. In the arrangement for railway and artillery carriages four of these breaks and life-guards are placed upon each carriage—one at each corner. The tongue of the life-guard and break block, clips the top of the kerb, thus securing the carriage to the railway.

The CHAIRMAN: We are much obliged to you, Mr. Wright, and I think your description has given us a fair idea of the principle of your plan. Probably there are gentlemen present who would like to ask questions, or to discuss the merits of these plans. If there is any gentleman who would like to make any observations upon what has fallen from Mr. Walker or from Mr. Wright, we shall be glad to hear him. If not, the proceedings of this evening may be considered terminated, and I am sure I am only expressing the opinion of every gentleman present in saying that we are extremely gratified by the interesting paper upon coast railways that we have heard from Mr. Walker, and also by the explanations of his principle of railway artillery which have been given to us by Mr. Wright. For my own part, I confess, with regard to what are called our foreign relations, that I do not apprehend we shall ever have anything to fear from actual invasion; but it is possible that a very annoying enterprize might be undertaken on our coasts, and under those circumstances nothing would be more important, no element more valuable, than that which would give us the means of concentrating artillery upon any particular point. Both the scheme of railways explained by Mr. Walker, and the coast artillery shown by Mr. Wright, are elements that very much conduce to that object. There is one thing evident, which is, that the best way to avoid that which we wish should not take place, is to be quite prepared beforehand for it. You will, I am sure, join me in an unanimous vote of thanks to Mr. Walker and to Mr. Wright for the interesting evening they have afforded us.
